TECHNICAL GUIDELINES

FOR

ON-SITE THERMAL DESORPTION

OF

SOLID MEDIA AND LOW LEVEL MIXED WASTE

CONTAMINATED WITH MERCURY AND/OR

HAZARDOUS CHLORINATED ORGANICS

-FINAL-

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ABOUT ITRC

Established in 1995, the Interstate Technology & Regulatory Council (ITRC) is a state-led, national coalition of personnel from the environmental regulatory agencies of some 40 states and the District of Columbia; three federal agencies; tribes; and public and industry stakeholders. The organization is devoted to reducing barriers to, and speeding interstate deployment of, better, more cost-effective, innovative environmental techniques. ITRC operates as a committee of the Environmental Research Institute of the States (ERIS), a Section 501(c)(3) public charity that supports the Environmental Council of the States (ECOS) through its educational and research activities aimed at improving the environment in the United States and providing a forum for state environmental policy makers. More information about ITRC and its available products and services can be found on the Internet at **www.itrcweb.org.**

DISCLAIMER

ACKNOWLEDGMENTS

The members of the Interstate Technology Cooperation Work Group (ITRC) Low Temperature Thermal Desorption (LTTD) Work Team wish to acknowledge the individuals, organizations and agencies that contributed to this Technical/Regulatory Guidance document.

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EXECUTIVE SUMMARY

The legal and regulatory uncertainties surrounding the cleanup of waste sites can discourage the testing and use of innovative technologies as well as innovative applications of accepted technologies. Technology developers often have difficulty gaining regulatory approval for the use of new technologies and may be required to demonstrate a technology's performance in each state targeted for technology deployment. In response to this concern, the Western Governors' Association convened a meeting of western regional regulators during the summer of 1994 to discuss ways to increase cooperation among states on the review, permitting, and evaluation of promising new remediation technologies. This group, the Interstate Technology and Regulatory Cooperation Work Group (ITRC), has been expanded to states outside the region and includes federal, industry, and stakeholder advisors as well. The ITRC is continuing in its work to recommend mechanisms to be incorporated into state policy to facilitate interstate cooperation, in order to shorten the time it takes technologies to go from demonstration to widespread application.

The ITRC Low Temperature Thermal Desorption (LTTD) Work Team previously developed a document which blends diverse state technical requirements for a proven technology, low temperature thermal desorption, used for treatment of nonhazardous soils. The work team considered requirements from nine states to develop their draft document, circulated the document for review and comment to all member states of the ITRC, and then distributed the document for concurrence among the ITRC states.

Using its first document as a template for two additional documents, the Work Team greatly reduced the time required to produce the subsequent documents. The second document, which deals with solid media contaminated with hazardous chlorinated contaminants, is currently undergoing the ITRC concurrence process. The third document goes a step further by addressing mercury and low level mixed waste issues. **However, because the use of thermal desorption to treat radioactive mixed waste is less well developed than for other applications, the LTTD Work Team chose to provide "guidelines" as opposed to "requirements" for this document.** Although this document touches on some regulations regarding hazardous waste, it is **not intended to summarize or interpret existing state or federal regulations**.

In keeping with the full ITRC, the LTTD Work Team views stakeholder involvement as a key element, when selecting new technologies for the cleanup of contaminated sites. The Work Team has adopted, in principal, the concepts put forward in "A Guide to Tribal and Community Involvement in Innovative Technology Assessment", developed by the participants of the DOIT Tribal and Public Forum on Technology and Public Acceptance.

In producing this product, the general goals of the LTTD Work Team were:

- to produce a model set of technical guidelines which would serve as a format for states;
- to improve market conditions for thermal desorption technology providers by providing a degree of consistency in technical guidelines;

- to further the process of interstate cooperation directed toward enhancing implementation of innovative technologies;

Thermal desorbers remove organic constituents from solids by raising the temperature of the contaminated material to a sufficiently high level to effect contaminant volatilization and transfer to a gas stream. Technical guidelines focus on achieving contaminant removal, fugitive emissions control, mechanical operability of the primary treatment equipment and efficient fuel combustion (where appropriate). These areas can be particularly complex when dealing with radioactive mixed waste.

It is important to note that state regulations may be more restrictive than the technical guidelines included in this document and that compliance with those more restrictive regulations is required unless a specific waiver pursuant to CERCLA or some other state statute is involved. Therefore, approval of the use of a thermal desorption unit at a site in one state should not be construed as approval to use the technology at another site in either the same or a different state. As in the two previous ITRC thermal desorption documents, **this document does not attempt to address whether any particular thermal desorption unit/or afterburner is classified as an incinerator.** There is great disagreement among states on this issue and individual states have varying policies on which type(s) of thermal desorbers are acceptable for use in their states.

Technical guidelines in this document are provided for the following areas:

- Pre-treatment Sampling
- Feed Limitations
- Treatment Verification Sampling
- Soil/Waste Handling and Stockpiling
- System Operating Guidelines
- Process Monitoring
- Automatic Shutdown
- Proof of Process (POP) Performance Testing for Air Pollution Control Systems
- POP Testing Frequency for Units Treating Contaminated Media
- Emissions Monitoring
- Water Discharge Monitoring
- Record Keeping
- Quality Assurance/ Quality Control
- Health and Safety
- Cost and Performance Reporting Guidelines

On some sites, states may choose to go beyond this set of guidelines. It is the responsibility of operators to find out from regulators whether there are additional or alternate guidelines applicable; and it is in the states' best interest to allow variances from these technical guidelines based on specific technology applications. Variances also should be considered to allow for the use of appropriate alternative sampling or analytical methods.

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1.0 INTRODUCTION

Thermal desorption is a treatment technology which is designed to remove contaminants from solid media (e.g., soils, combustible solids) by volatilizing them with heat in the primary chamber, but without combustion of the media or contaminants. However, incidental combustion may occur in some primary thermal desorption units. The desorbed contaminants are then treated in the secondary unit to control air emissions. Some configurations of this technology destroy the contaminants with an afterburner or other thermal device. Other configurations collect the contaminants for later treatment using condensation and carbon adsorbtion, etc. Thermal desorption has been widely used in treating petroleum contaminated wastes and is being used increasingly in the cleanup of hazardous solid media and low level mixed waste, notably those containing mercury, chlorinated solvents, chlorinated pesticides, and polychlorinated biphenyls (PCBs).

1.1 Scope of Document

This document deals with the treatment of solid media and certain low level radioactive mixed wastes contaminated with mercury and/or hazardous chlorinated organics such as chlorinated solvents, chlorinated pesticides, and PCBs through the application of thermal desorption technologies. **The Low Temperature Thermal Desorption (LTTD) Work Team has designed this document to summarize the technical information and procedures necessary to demonstrate the operating capabilities of the thermal desorption unit. This document is not designed to summarize or interpret existing state or federal regulations.**

The guidelines presented in this document are directed toward relatively small, short term, on-site projects as opposed to permanent treatment, storage and disposal (TSD) facilities. For purposes of this document, small, short term projects will be regarded as projects which process about 20,000 cubic yards or less of contaminated material and operate on-site for roughly six months to one year. Because of the wide range of variations from state to state, this document does not address cleanup criteria for soil, water, air or waste classification sampling requirements.

This document has been developed for units used for the treatment of material contaminated with hazardous substances, as well as hazardous wastes which are assumed to be subject to Resource Conservation and Recovery Act (RCRA) Part 264, Subpart X requirements (Subpart X). Some technical guidelines presented in this document have been drawn from RCRA Part 264, Subpart O requirements (Subpart O); however, this document does not attempt to address whether any particular thermal desorption unit and/or afterburner is classified as an incinerator. That determination, along with associated requirements, will be made by individual states and states are

still free to regulate a unit under Subpart O. A recent letter from the US EPA on this issue can be found in Appendix C of this document.

The focus of this document is on-site treatment using thermal desorption processes. In instances where waste is accepted from additional sites, more emphasis should be placed upon waste analyses prior to treatment to insure that the waste can be effectively treated by the unit and that the wastes placed in the unit do not react with each other.

In producing this document, the goals of the Low Temperature Thermal Desorption (LTTD) Work Team were:

- to produce a standard set of technical guidelines which could serve as a model to allow thermal desorption technology to move from state to state, without unnecessary redevelopment of technical guidelines;

- to improve market conditions for thermal desorption technology providers by providing a degree of consistency and predictability in technical guidelines for implementation of the technology for cleanup;

- to develop a viable, repeatable process for interstate cooperation directed toward enhancing implementation of innovative technologies and innovative application of existing technologies to site cleanup;

- to provide a framework for states which have no specific regulatory requirements for thermal desorption should they choose to develop those guidelines and to provide a gauge for states which do have guidelines to assess those guidelines in light of the common guidelines of other states;

- to provide a template of technical guidelines which could be used as a model for other technologies for all functions presented above.

1.2 Permitting/Approval Considerations

This document sets out <u>technical</u> guidelines for the permitting/approval to operate thermal desorption units. Although the document may touch on some regulatory requirements regarding hazardous waste, it is not intended to be a regulatory requirements document. It does not provide details on the applicability of various state and federal hazardous waste regulations or air pollution control regulations to thermal desorption. Since states must administer the regulations that exist in the particular state where the application of this technology is desired, it is strongly recommended that these issues be discussed with state regulators early in the planning process.

All uses of radioactive material (RAM) including treatment, storage and disposal must be specifically authorized by an appropriate regulatory authority. This approval varies based on the origin of the radioactive material as well as the location of the regulated activity, and can come from

the United States Department of Energy (DOE), the United States Nuclear Regulatory Commission (NRC) or an NRC authorized Agreement State agency. It is important to understand that regardless of United States Environmental Protection Agency (EPA) or similar approval for the hazardous waste operations, specific approval must also be granted for the RAM operations, usually from a separate regulatory authority.

For RAM generated by the DOE and for a regulated activity performed at a DOE facility, the principal approval authority resides with the DOE. This authority is granted by DOE after following detailed radiation protection procedures that are required by "DOE Orders." Each DOE facility has its own set of procedures that implement the DOE Orders.

If the regulated activity is performed at a commercial facility (other than a nuclear power plant) this authority is granted in a radioactive materials license issued to the facility operator by the NRC or an authorized Agreement State agency. Throughout this document, when the term "NRC" is used in reference to an approval authority, it means either the USNRC or the appropriate state agency in an NRC agreement state. The license is usually for a specific use that must include the thermal desorption unit operations in the context of this document. The operation is conducted under the radiation protection standards of the NRC as given in the Code of Federal Regulations (CFR), specifically 10 CFR 20, or State rules that are equivalent to the NRC standards.

For RAM operations conducted at a nuclear power plant, the NRC is the regulatory authority. Thermal desorption operations on low level waste would normally be authorized based on the power plant licensee performing and documenting a detailed review to determine that no new hazards are presented by the thermal desorption unit operation, and that the thermal desorption unit is constructed and operated according to existing NRC regulatory guidance for rad waste treatment equipment.

Many states have opted to obtain authorization from the EPA to administer hazardous waste programs in lieu of the federal RCRA program. To obtain authorization, states have had to adopt rules, regulations and/or standards that are equivalent to RCRA. For example, one such requirement is that no person shall treat, store or dispose hazardous waste without a permit. However, specific exclusions are afforded and some states, through institution of state cleanup programs, have opted to exclude remediation projects from hazardous waste permitting.

For sites that are on the National Priority List (NPL) under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), no administrative requirement exists to obtain a permit; however, in conjunction with the finalization of a record of decision, all federal, state and local applicable or relevant and appropriate requirements (ARARs) must be identified and addressed. While in some states a hazardous waste permit may be required, clearly the importance of understanding the regulatory requirements associated with a site cannot be underestimated.

It is important to note that state regulations may be more restrictive than the minimum technical guidelines included in this document and that compliance with those more restrictive regulations is required unless a specific waiver pursuant to CERCLA or some other state statute is involved.

Therefore, approval of the use of a thermal desorption unit at a site in one state should not be construed as approval to use the technology at another site in either the same or a different state.

Because there are many types of thermal desorbers (e.g., indirect vs. direct fired units) and because there are many different methods for handling desorbed contaminants by air pollution control (APC) systems (e.g., carbon absorption units v.s. afterburners) many state and federal regulations could be interpreted by various states to apply to a particular system. In particular, gas treatment and/or APC systems involving the recovery of organics must provide air emissions control within state and federal limitations. Some states may impose requirements for "best" or "maximum" available control technologies for specific air pollutants.

There are federal regulations that apply to hazardous waste treatments which are similar to thermal desorption; however, none of these treatments truly fall into the class of thermal desorption. RCRA Subpart O of the Code of Federal Regulations applies to incineration of hazardous waste. Some states may regard certain thermal desorption units and/or afterburners as incinerators and therefore require compliance with Subpart O. Subpart AA applies to process vents where mechanisms similar to those used in thermal desorption are employed. The types of activities specified in that regulation do not include thermal desorption of contaminated media; nevertheless, some states still may require compliance with Subpart AA provisions for thermal desorption units.

1.3 Process Overview

1.3.1 Background

The legal and regulatory uncertainties surrounding the cleanup of waste sites discourage the testing and use of innovative technologies as well as innovative applications of accepted technologies. Technology developers have difficulty gaining regulatory approval for the use of new technologies. Their difficulties are compounded by the requirement for developers to demonstrate a technology's performance in each state targeted for technology deployment.

In response to this concern, the Western Governors' Association convened a meeting of western regional regulators during the summer of 1994 to discuss ways to increase cooperation among states on the review, permitting, and evaluation of promising new remediation technologies. This group, the Interstate Technology and Regulatory Cooperation (ITRC) Working Group, has been expanded to states outside the region and includes federal, industry, and stakeholder advisors as well. The ITRC is continuing in its work to recommend mechanisms to be incorporated into state policy to facilitate interstate cooperation, in order to shorten the time it takes technologies to go from demonstration to widespread application.

In 1996 the LTTD Work Group, consisting of regulators from California, Florida, Illinois, New Jersey, New York and the EPA, developed a consensus based set of technical requirements for use of thermal desorption in the treatment of soils contaminated with petroleum/ coal tar and manufactured gas plant wastes. The next year, the LTTD Work Team expanded the group to include representatives from California, Florida, Illinois, New York, Tennessee, the Environmental

Protection Agency, the US Department of Energy, the US Army Corps of Engineers, private industry and stakeholders to better address an expanded scope for the use of thermal desorption.

1.3.2 Approach

The LTTD Work Team previously developed a document which blends diverse state technical requirements for a proven technology, low temperature thermal desorption, used for treatment of nonhazardous soils. The work team considered requirements from nine states to develop their draft document and circulated the document for review and comment to all member states of the Interstate Technology Regulatory Cooperation Work Group.

The work team used its first document as a template for two additional documents, greatly reducing the time required to produce the subsequent documents. The second document, which is currently undergoing the ITRC concurrence process, deals with solid media contaminated with hazardous chlorinated compounds such as PCBs, chlorinated solvents, and pesticides and addresses the associated broader range of temperatures for thermal desorption treatment. Requirements for chlorinated organics were "layered" onto the original text to address some of the more complex issues of treating hazardous wastes. The third document goes a step further by addressing mercury and low level mixed waste issues. **However, because the use of thermal desorption to treat radioactive mixed waste is less well developed than other applications, the LTTD Work Team chose to provide "guidelines" as opposed to "requirements" for this document.**

This document was distributed in draft form to ITRC member states, as well as to other interested parties for review and comment. The LTTD Work Team reviewed and discussed each comment submitted and based upon consideration of that input, finalized the document. This document has been distributed to ITRC states' POCs for the concurrence process.

1.4 Assumptions

In preparing this document, the LTTD Task Group used the following "basic assumptions."

- The LTTD group has elected to produce a common set of technical guidelines for all thermal desorption applications. Because of the wide diversity of thermal treatment technologies, the group feels it is not feasible to establish a detailed test plan appropriate for all sites.

- These technical guidelines were developed to provide stakeholders (including vendors) with some degree of predictability and consistency of technical operating guidelines from state to state. However, individual state's regulatory requirements have not been evaluated and states reserve the right to go beyond these guidelines, but are encouraged to provide the rationale for doing so.

- Alternatives to these guidelines may also be acceptable, on a case specific basis, but there should be a technical basis for the alternative.

- Because of the wide variability among states, these technical guidelines do not include any emission criteria for air or cleanup criteria for soil or water.
- The term “hazardous” is as defined by the Resource Conservation and Recovery Act (RCRA), but for purposes of this document will include Toxic Substances Control Act (TSCA) regulated PCBs.

- For purposes of this document, the term “low level mixed waste (LLMW)” refers to waste that is contaminated with both hazardous and radioactive constituents. The radioactive components include non-trans-uranic (TRU) material (i.e., < 100 nCi/g TRU isotopes), naturally occurring radioactive material (NORM), as well as conventional low level waste (LLW) as defined by the United States Nuclear Regulatory Commission (NRC). Additionally, the guidelines in this document apply to many nuclear fuel cycle wastes other than high level wastes that are regulated as radioactive materials, such as byproduct material (e.g., mill tailings) and various forms of uranium (depleted, enriched, special nuclear materials).

- Issues relevant to nuclear criticality have not been addressed, and these should be carefully reviewed.

- These technical guidelines are appropriate only for contact handleable, low surface dose, non-volatile radioactive materials that are less than 100 nanocuries TRU per gram and are within radioactivity levels that meet containment structure controls. The following conditions are beyond the scope of this technical guidelines document and require more detailed review of radiation issues: TRU isotopes > 100 nCi/g, radioactivity levels exceeding specific building or containment structure limitations, the presence of tritium (H-3) or carbon-14, radiation dose rates exceeding contact handleable levels (i.e., greater than 1- 10 mR/hr at 1 meter).

1.5 Special Considerations for Treating Hazardous Waste

Thermal desorbers remove organic constituents from solids by raising the temperature of the contaminated material to a sufficiently high level to effect contaminant volatilization and transfer to a gas stream. Various thermal desorption technologies employ differing combinations of temperature, time, mixing and vacuum to perform this transfer. Wide ranging soil characteristics in combination with contaminant properties make it very difficult to provide meaningful guidelines on this key operational step. Technical guidelines are highly specific to the particular approach and focus on achieving contaminant removal, fugitive emissions control, mechanical operability of the primary treatment equipment, and efficient fuel combustion (where appropriate).

Two classes of thermal desorber units have emerged: indirect (Figure 1-1) and direct fired units. (Figures 1-2 and 1-3). In either approach, heat from the combustion of fuel in burners is applied to the soil to evaporate the organic chemical and remove it into a gas stream. Some of the major engineering/design differences are discussed below[1].

FIGURE 1-1

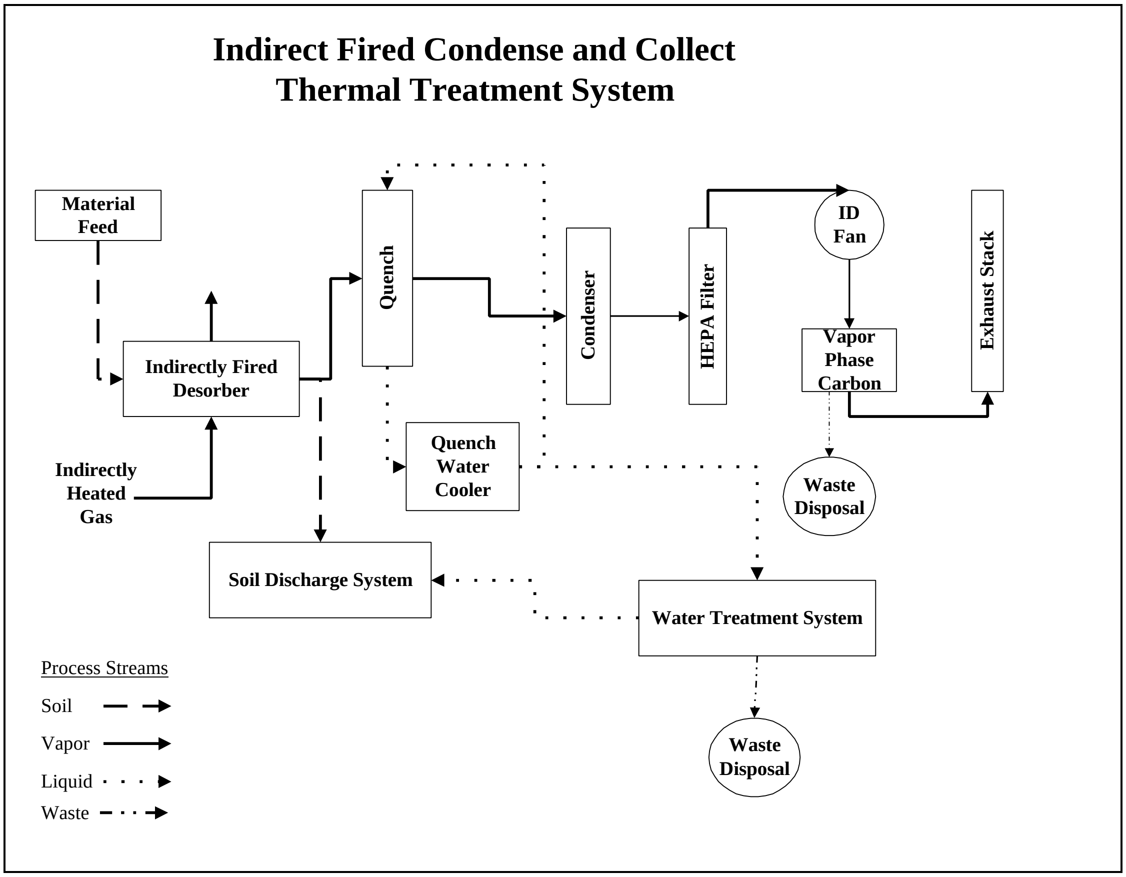

Figure provided by Maxymillian Technologies, 1998.

[1] This document does not endorse one type of unit over the other and (as discussed earlier in Section 1.1) and does not attempt to determine whether any particular unit is acceptable either from a public or and individual state regulatory standpoint.

In an indirect fired unit, the heat is conducted to the waste through metal walls or with a medium such as heated gas. Recovery of the contaminant is much simpler for an indirect fired unit, because a high volume combustion gas is not present and only the small volume of contaminant and process gas should be managed in the recovery system. Furthermore, control of the oxygen concentration can be readily effected, minimizing or eliminating oxidation of the organic material and allowing its complete recovery. Recovery units require off-site disposal or recycling of the concentrated organic chemicals.

FIGURE 1-2

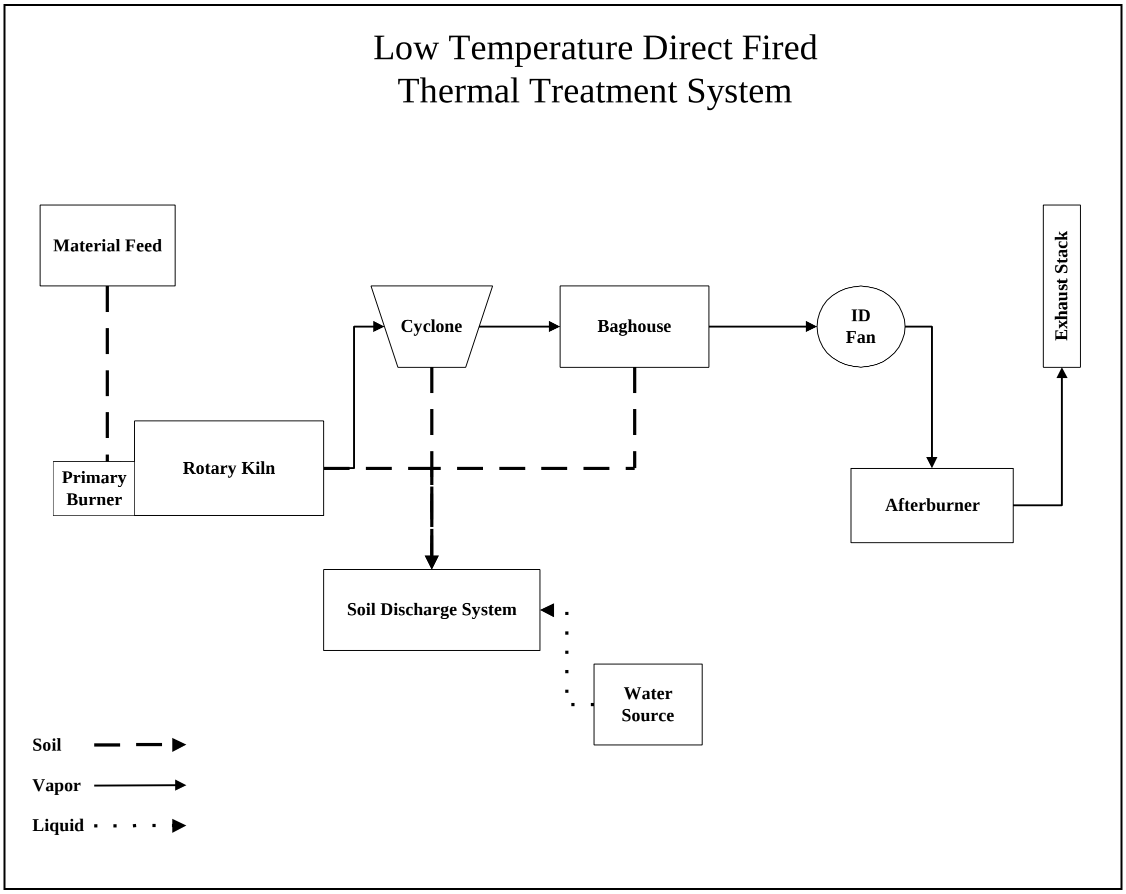

Figure provided by Maxymillian Technologies, 1998.

In a direct fired unit, the burner gases are intimately mixed with the waste and/or waste gases. The direct fired unit can be operated either to completely oxidize the desorbed organic chemical or to recover part of most of it from the gas stream.

FIGURE 1-3

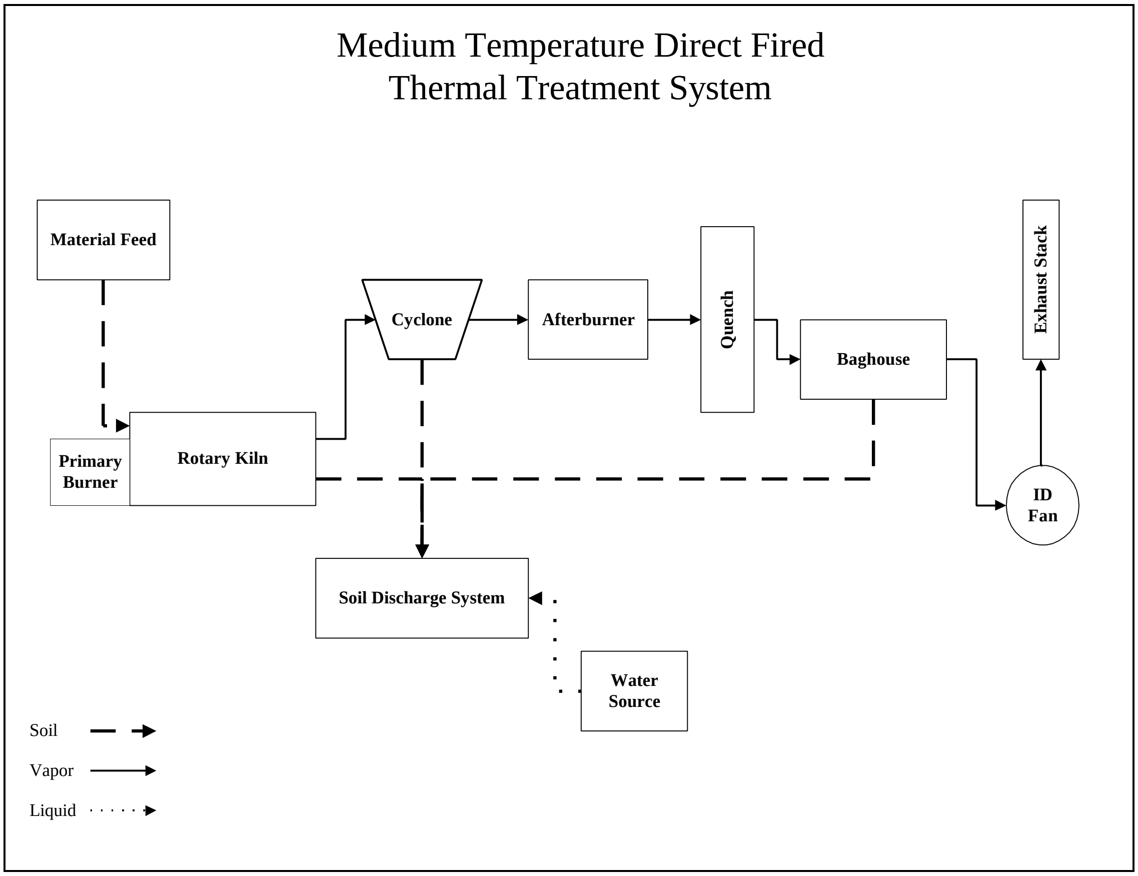

Figure provided by Maxymillian Technologies, 1998.

Two significant differences exist between the indirect and direct fired units: 1) the degree to which air emissions can be controlled and 2) their operating production rate and corresponding cost of operation. When large volume media such as soil is subjected to thermal desorption treatment, the heat input required to remove the organic contaminants yields a very large volume of combustion gases from the burners. Very high heat rates and resulting production rates result from mixing the burner gases with the contaminated soil in a direct fired unit. When the gases are mixed with the hazardous waste or desorbed waste gases, then the entire gas stream must be controlled prior to emission to the air. When EPA technical specifications and guidance are followed, these control devices can become extremely expensive to build and operate. However, since concern for air emissions increases with the introduction of chlorinated organics and possibly even dioxin precursors into the thermal desorber, technical specifications for management of air emissions (e.g., complete destruction of chemicals, scrubbing and filtering of exhaust gases to remove the products of combustion) cannot be relaxed.

An indirect fired unit, with a low volume gas stream to manage, can be more cost effective than the direct fired unit while still achieving exceptional control of emissions. Even though the heat rate

is much lower because burner gases are separated from the waste and waste gases, the smaller control devices can be operated at high efficiency and low cost. This balance among technical specifications, air emissions, production capacity and cost is significant, and will define the remedy selected for each site under consideration for thermal desorption treatment.

When a thermal desorption unit employs direct firing of the primary, an additional removal mechanism can exist whereby the organic contaminant can be partially or completely oxidized. This improves contaminant removal from the solids at lower treatment temperatures, and can extend the range of applicability of a direct fired unit. In these units, additional technical guidelines become significant. Another issue is that certain inorganic constituents when present in the solids (i.e., lead, chrome) can easily be oxidized to increase their toxicity and mobility in the treated solids or residuals, invoking additional technical and monitoring requirements for metals.

For direct fired units, design and operating standards shall be applied to either the primary chamber or the downstream air pollution control system to maximize combustion of the principle organic hazardous constituents, as well as elimination of the products of incomplete combustion. Significant research and operational experience have confirmed the importance of both minimum technical specifications on the equipment and procedural requirements for its operation to assure a high level of performance in both normal and upset conditions.

This experience has shown that, for conventionally designed and operated units, effective operation has been achieved with a minimum gas temperature of $1{,}800^{o}$ F at the outlet of the afterburner; for PCB's this minimum temperature has been $2{,}000^{o}$ F. Also, the residence time for gas in the afterburner is normally maintained for more than two seconds. The carbon monoxide level in the undiluted stack gas has been found to be an easily measured surrogate for destruction/removal efficiency (DRE). Significant data exist showing that when carbon monoxide is maintained at less than 100 ppm in the stack gas, high DRE is assured. Finally, it is considered standard technique to supply enough excess oxygen to provide efficient combustion and to monitor the oxygen level continuously to assure its adequacy. To ensure high DRE throughout the remedial operations, all of these parameters are verified during the proof of process (POP) test and are also interlocked with the feed system to cause automatic waste feed cutoff if they are out of specification.

Basic safety dictates the importance of strict limitations on the maximum organic material feed rate to these units. Excessive feed rate can overheat the equipment components from heat released during combustion and cause mechanical failure and possible uncontrolled emissions. It is normal practice for the treatment unit designer to determine the maximum organic waste feed rate that is safe. Physical and/or administrative methods to measure and limit the feed rate are then developed and implemented to prevent overheating of the unit during remedial operations. This constraint does not apply to units that have positive measures to prevent combustion in the primary unit (e.g., indirect heated units with gas seals and inerting systems).

When the gas treatment and/or air pollution control systems involve the recovery of the organic contaminant by condensation, carbon adsorption or similar technique, the focus of the technical

requirements for this equipment is on air emissions control within state and federal limitations. Issues exist regarding both the preservation of local ambient air quality and the emission of toxic or hazardous air pollutants. Additionally, states may impose requirements for "best" or "maximum" available control technologies for specific air pollutants.

When the gas treatment system involves an afterburner for the destruction of the organic compounds, additional technical guidelines become significant. Design and operating standards that maximize combustion of the principle organic hazardous constituents and elimination of the products of incomplete combustion shall be applied to the afterburner (or similar component of the air pollution control system). These technical standards involve afterburner operation at very high gas temperatures.

For direct fired units, solids carryover from the primary unit of 20% or more is common. For indirect fired units, 3 to 12% is common. If the contaminated solids contain certain volatile metals (e.g., lead, arsenic, cadmium), they may be vaporized from dust particles at these high temperatures and may cause air emissions issues, as they are difficult to control with downstream air pollution control devices. These metals transport issues are exacerbated when certain radioactive materials such as cesium are present, because these too can be vaporized at high temperatures and transferred though the gas system, causing both emissions and residuals management complexities. Also, air pollution control (APC) dust or ashes can exhibit altered metals leachability from oxidation. Both of these issues invoke additional technical and monitoring requirements with respect to metals.

1.6 Special Considerations for Hazardous Waste Units Treating Dioxin/Furan Precursors Including Polychlorinated Biphenyls (PCBs)

There are two dioxin/furan issues related to thermal desorption: 1) the possible formation of dioxin/furans during thermal desorption treatment, and 2) the fate of any dioxin/furans created by the thermal desorption system or innate to the impacted media in the thermal desorption system. It has been demonstrated[2] that well operated thermal desorption systems can avoid forming dioxins/furans. However, during a USEPA SITE demonstration[3] there was evidence that thermal desorption systems can form dioxin/furans under certain conditions.

[2] USEPA-ORD, July 1995; USEPA-ORD, Feb 1993 and USEPA-ORD, December 1992.

[3] USEPA-ORD, December 1992.

Factors causing dioxin formation during this demonstration included long residence times at a temperature of 650° F, existence of chlorinated organics, and addition of ferric chloride to the sediments during dewatering. There are many other factors that impact the creation of dioxin/furans[4], but the full discussion of these factors is outside the scope of this document. (The cited reference is one of many documents that address the dioxin/furan formation issue).

If a site has been contaminated with chlorinated aromatics, there may be small amounts of dioxins/furans in the soil. Because the untreated soils may contain many interfering humic and chlorinated aromatic organics, the dioxin/furans analytical detection limits may be raised to a point above the dioxin/furan soil concentrations. Consequently, these dioxin/furans may be detected in the soil only after treatment. In this case, post-treatment detection of dioxins/furans does not mean that dioxin/furans were formed as a result of thermal desorption treatment, but rather that the interfering compounds have been removed from the soil through treatment and thus the detection limits are much lower.

Regardless of the thermal desorption unit's operating temperature, there is evidence that dioxin/furans contamination is removed from soil to a certain degree. It is believed that co-distillation or co-volatilization of the dioxin/furans with the soil moisture and/or contaminants is the mechanism. As expected, the higher the thermal desorption operating temperature the greater the dioxin/furan removal from the soil. Temperatures of 900° F to 1100° F [5] have been identified as the requirement to actually remove dioxin/furans from contaminated soil to the part per trillion (ppt) level.

Whether occurring in the soil or formed in the process, dioxins/furans are usually collected and concentrated in the air pollution control (APC) system. Dioxin/furans frequently "ride" with small particulates into the APC system. Thus, the filter/baghouse dust may have detectable levels of dioxin/furans. Further, if there is sufficient organic contamination to have an organic phase from the condensers and/or scrubbers, detectable dioxin/furans may occur, since dioxin/furans are much more soluble in organics than in water. Carbon adsorption is frequently used to treat both the gas and aqueous residuals before discharge or reuse, since carbon adsorption has been found to be very effective treatment for dioxin/furans and other heavy organic contaminants. To insure that unacceptable levels of dioxin/furans are not emitted to the atmosphere, stack gas sampling for dioxin/furans is recommended, if dioxin/furan precursors such as chlorinated aromatics exist in the feed media. (See Section 7.3 of this document).

[4] Addink and Kees, 1995.

[5] Ayen., Palmer, and Swanstrom, 1994.

It should be noted if the feed material is derived from materials which contain more than 50 mg/kg PCBs, Toxic Substances Control Act (TSCA) regulations will apply. For federal NPL sites, no TSCA permit is required, however, substantive compliance is required. For state lead sites which contain more than 50 mg/kg PCBs, a TSCA permit is required.

When thermal desorber units are used to treat waste containing PCB, PCP or pesticide contamination which is also contaminated with radionuclides, temperature ranges required for treatment of these constituents in the secondary unit can create new problems. The by-products that may be generated at the required higher treatment temperatures can facilitate the mobility of the radionuclides into the environment. One option is to limit treatment temperatures in the secondary unit to below that which favors the emission of other hazardous compounds. Also of concern are those temperatures at which the radionuclides would volatilize.

1.7 Special Considerations for Hazardous Waste Units Treating Mercury

Mercury contamination is a fairly widespread problem, not only for the Department of Energy (DOE) but all across the environmental restoration industry. Although all soil thermal desorption devices have the ability to heat the media and thus to vaporize most mercury species, the ability to successfully treat mercury impacted soil is dependent both on the configuration of the thermal desorption hardware and on the mercury species involved (the historical source).

In comparison to other thermal desorption processes, many mercury processes are batch processes, should be run with low volumes of air, and may have inherent limitations. The application of thermal desorption to mercury impacted soils and/or mercury bearing waste requires several changes from thermal desorption processes commonly used on hydrocarbon impacted soils. The changes include modifications of the materials handling and preparation system, control of fugitive dust emissions, operation of the thermal desorption unit, and treatment/control of the air emissions. Because mercury may change easily from metal to oxide form, the system should be designed to control oxygen levels.

Another related treatment for mercury is mercury retort, which is thermal desorption without agitation. In general, requirements for the retort system are very similar to thermal desorption, except that following desorption there should be some type of mercury collection or stabilization system. For example, a system now being used at the Rocky Flats Environmental Test Site amalgamates the mercury with sulfur after thermal treatment. Other mercury recycling units deal with mercury strictly as a hazardous waste (e.g., florescent light bulbs).

The most significant forms of mercury (Hg) found in the environment are elemental mercury and inorganic mercury (Hg II) compounds including $Hg(OH)_2$, HgS, $HgCl_2$, and methyl mercury (CH_3HgX) compounds. The high vapor pressure of $HgCl_2$ makes this compound difficult to condense; however, it can be easily scrubbed through the air pollution control system. Methyl mercury species are the most toxic and environmentally mobile; as such, they represent the greatest health and safety challenges. It may be difficult to obtain repeatable sampling results because

mercury is often heterogeneously distributed with small, highly concentrated agglomerations. Therefore it is important to have a well-developed sampling and analysis plan (SAP). An excellent reference regarding the importance of all aspects of sampling and analysis plan development is the *Quality Assurance Project Plan for Characterization Sampling and Treatment Tests Conducted for the Contaminated Soil and Debris (CSD) Program prepared by the* USEPA Office of Solid Waste [6]. Treatment standards for mercury are not well understood. LDR determination for mercury is not necessarily straightforward and is not concentration dependent. Form (e.g., Hg metal, Hg oxide, Hg sulfide) seems to play a larger role in toxicity and TCLP.

Excavated, untreated mercury impacted soil can emit mercury vapors at sufficient levels to cause unhealthful situations to the site workers and other nearby human populations. Control of storm water which has the potential to come in contact with untreated soil shall be addressed. Controlling the off-gas and then maintaining safe levels of mercury in the air discharged from the system are also challenging aspects of treatment system design and operation. Some vendors use condensation (both primary and secondary), air scrubbing, sulfonated carbon, or combinations of these air treatment technologies. Mercury sensors are available to provide on-the-job mercury vapor measurements thus enhancing the potential for job site safety and control.

An additional area of special concern for mercury is the disposal of secondary waste. For example, mercury is removed from soil and concentrated, but then must be put in a disposable form. It is not destroyed or collected in the same way as VOCs are.

1.8 Special Considerations for Treating Low Level Mixed Waste (LLMW)

To achieve the optimal operation of a thermal desorption unit in service on mixed waste, the objective of the treatment is to remove the organic and/or mercury contaminants from the solids while retaining the radioactivity in the solid matrix. Ideally, this would yield both “nonhazardous” radioactive solid waste for disposal, and nonradioactive waste streams for recycling, disposal or further treatment. Achieving this objective is highly specific to the equipment and its operating parameters. It should be noted that recovery of contaminants from radioactive material has the potential to create additional radioactive effluent, resulting in the need for more containment control, different ventilation rates and additional specialized effluent monitoring. Residues in recovery systems might also be radioactive and require specialized disposal. Engineering controls are needed to insure that increases in volumes of radioactive wastes (effluents, emissions) as a result of treatment are kept to a minimum.

Two other acceptable treatment objectives exist that may invoke additional special requirements on the management of the solid and liquid waste streams. One is to remove enough of the hazardous constituents from the solids to achieve either the land disposal restriction universal treatment standards (LDR UTS), as set forth in 40 CFR 268.48, or similar site specific laydown standards. Meeting this treatment objective will thereby allow disposal of the radioactive solids in a mixed

[6] USEPA Office of Solid Waste*, Nov. 8, 1990.*

waste landfill or on-site disposal facility which will accept the waste. The other acceptable objective is to generate radioactive process residuals such as condensed oil and/or water that meet a permitted TSD facility's waste acceptance criteria, and ship those materials there for treatment and/or disposal.

The application of thermal desorption to mixed waste raises several unique issues and requires several changes from the thermal desorption units used to manage hazardous wastes. When designing the system, four issues stemming from the radioactivity of the waste become paramount:

- minimizing worker exposure to assure worker safety and compliance with the principle of maintaining radiation exposures as low as reasonably achievable (ALARA)
- minimizing release of radioactive substance to the environment
- minimizing secondary waste generation during all aspects of the operation.
- maximizing containment of radioactivity during all aspects of the operation.

Process residuals can be generated that have little or no presently permitted disposal capacity. Emissions limitations can exist that render otherwise routinely used APC devices unacceptable (such as baghouses for particulate matter control). Treated solids and radioactive process residuals must be handled to assure absolute containment of radioactivity, rendering obsolete many material handling systems used on hazardous thermal desorption units, where dust emissions are controlled only to prevent nuisances at the site.

It is extremely important to recognize that there must be positive engineering controls on all systems and components that handle or process the radioactive materials. These units must be provided with features to eliminate or control potential air emissions, as well as surface contamination on the equipment and in the process area. In addition to being required by statutory radiation protection standards, these engineering controls reduce the cost of operation by containing the radioactive waste and reducing or eliminating radioactive contaminated secondary waste (trash) from contamination cleanup or prevention.

Excellent pilot testing results have been achieved with specially designed and operated thermal desorption units on mixed wasted from Oak Ridge, Rocky Flats, Savannah River Site, Los Alamos, Pantex, Idaho National Environmental and Engineering Lab (INEEL), and several others. Small scale commercial operations have been conducted at INEEL, Rocky Flats, a CERCLA site in New Jersey and a commercial generator's facility in Texas. These results confirm the basic benefits of thermal desorption operations on mixed waste, but also reinforce the importance of the key issues.

The main components of thermal desorption units that have proven effective on mixed waste treatment are a thermal treatment vessel, a gas treatment system and a final filtration system to control vapor emissions before they are exhausted to the atmosphere. These components are present in various commercially available thermal desorption systems that are designed for either hazardous or mixed waste. However, when dealing with radioactive materials, the system must be designed to both minimize and monitor dust that is generated during operation. The unit must also minimize transfers that create secondary waste streams from necessary contamination control requirements.

Dust monitoring is normally performed by either local area monitors (e.g., selective ambient air monitors or SAAMs) with alarms, or routine local air monitoring by grab samples (i.e., a high volume sampler) and immediate radiation counting of the sample filter.

Site owners, regulators and treatment vendors will find the disposal of the treated solids to be far more restricted than for soil from a hazardous thermal desorption unit because the material is radioactive. Process residuals, which include scrubber blowdown and sludges, condenser oils and water, spent filter media (i.e., carbon) from air and water treatment components, decontamination and closure wastes, and contact waste from operation of the unit (i.e., personal protective equipment), must also be carefully scrutinized for acceptable permanent disposal.

In addition to air emissions limitations on the hazardous constituents of the material, there will be limits on the radioactive emissions. From a regulatory perspective, these are implemented both by USEPA and US Nuclear Regulatory Commission (NRC) as limits for the radiation dose to workers and the public. Clean Air Act regulations 40 CFR 61, Subpart H Radionuclide National Emission Standards for Hazardous Air Pollutants (RADNESHAPS) govern radionuclide emission from facilities. Any new source of radionuclide air emissions must be approved by the EPA before operations commence, unless specific exemption limits are met (i.e., <0.1 mR/yr for the unit or <1 mR/yr for the facility). In new operations at non-DOE facilities, the RADNESHAPS permit is granted by a State agency rather than the USEPA, following the same standards as imposed by USEPA. However, from a practical standpoint, for all but very few radioactive isotopes, the limit will most frequently be no detectible emission. In almost all cases, this will require absolute control of particulate matter by passing potentially radioactive emission streams through HEPA filters. This constraint rules out many conventional thermal desorption unit designs based on cost and performance factors.

Material handling during feed preparation, feeding, product discharge and residuals management will all require substantially different approaches than the bulk material handling methods that are common for hazardous waste thermal desorption units. The revised approaches must meet the additional requirements to provide complete containment of radioactivity during these procedures, both to control emissions and to limit worker exposure to radioactive materials. Sorting, screening and shredding are processes that are not especially amenable to radioactive materials containment. When debris materials are to be treated, they require shredding to a four-inch or smaller size to comply with the debris rule (40 CFR 268.45) and system specific limitations.

During pilot testing conducted by Rocky Flats, the entire sorting area and shredder were enclosed in a negative pressure containment tent with HEPA filtered exhaust. Material was charged to and removed from the shredder using gloves that were an integral part of the wall of the tent. Although these methods proved adequate for a short-term test operation, more rigorous engineering controls on the shredder would be needed for production operations. Bag-in and bag-out[7] techniques are

[7] Bag-out process is a process by which radionuclide contaminated waste is removed from a radiological contaminated zone using special bags. The process uses a poly-bag with an elastic opening, at one end, which fits snug around the opening to the contaminated zone. The product is removed from the zone through the opening and

often required to feed radioactive material to the thermal desorption unit and remove it from the product discharge. These procedures were developed and proved completely effective for the Rocky Flats DOIT demonstration in 1995. They have been further implemented with complete success on plutonium contaminated mixed waste at radioactivity levels up to 65 nCi/gm.

Analytical sampling of the feed and treated material causes worker exposure to radioactive materials and can generate additional, difficult-to-manage radioactive and mixed waste from analytical residues. For all mixed waste, attempts must be made to reduce the amount of sampling to the minimum necessary to meet regulatory requirements and also to provide the necessary information for safe operation of the system. Preference should be given to thermal desorption processes that have excellent mixing and aggressive treatment conditions, both of which promote reduced sampling frequency to confirm adequate treatment. Sampling of representative treated material should be conducted in a way that assures minimal worker exposure.

With respect to feed material characterization, there is a significant difference between environmental (in the ground) waste and legacy waste (radioactive materials operations waste in individual waste containers). Legacy waste poses major challenges for characterization and segregation of nonhomogeneous materials because it may consist of gloves, equipment, absorbed liquid waste, metal, hardware, radioactive products in various chemical and physical forms, etc. Characterization is difficult because of this heterogeneity and therefore the thermal desorption system should be designed for the worst case waste stream (for physical, chemical and radioactive characteristics).

1.9 Status of Thermal Desorption Use for Hazardous Waste and Mixed Waste

passed into the bag. The bag is twisted multiple times and tied off with a tape. The severed ends are taped into pig-tails.

The use of thermal desorption has advanced to the point where many states have approved/permitted some thermal desorbers for hazardous waste treatment. The earliest documented, full-scale use of thermal desorption for the treatment of organic hazardous waste constituents was at a Superfund site in Maine in 1987. Since that time, various embodiments of the technology have been used for the treatment of chlorinated organic chemicals impacted media. Organic contaminants may range from high volatility solvents such as trichloroethylene (TCE); to intermediate boiling compounds such as organochlorine pesticides; to extremely low volatility compounds such as PCBs, pentachlorophenol, and dioxins. Extensive pilot scale and treatability study experience has demonstrated that chlorinated organic chemicals can be effectively removed from soils and similar solid media to very low residual levels [8]. Solid matrices demonstrated include soil, sediments, lagoon sludges, process filter cakes, and similar solids. More recent experience has been gained with batch fed units treating both geologic and man made debris materials.

To date, the majority of the full scale operating experience with thermal desorbers in hazardous waste service has been at Superfund sites or at sites managed under state "Superfund" programs. This trend developed because these programs contain provisions for expedited operating approval which facilitate the performance of cleanup activities, even when operating standards and permit doctrine for the new technology are not yet developed.

[8] Ayen, Palmer, and Swanstrom, 1994.

Two classes of thermal desorber units have emerged: direct and indirect fired units. In virtually all cases, through the careful selection of design and operating conditions that are appropriate for the specific chlorinated organic chemicals in the waste matrix, the contaminant removal efficiency is the same for these fundamentally different thermal desorption approaches.[9] Technical considerations for these units are presented in Section 1.5 Special Considerations for Treatment of Hazardous Waste.

By reviewing results from example full-scale thermal desorption operations, decision makers can identify operations and cost issues which can help them to achieve the proper balance in the field. Several sites, contaminated with chlorinated organic chemicals, have been cleaned up using direct-fired thermal desorbers with production capacities as high as 50 tons/hour. At sites where the contamination largely consisted of chlorinated alkanes or organochlorine pesticides of low concentration, emissions control has been achieved using either an afterburner with moderate temperature and residence time or activated carbon adsorption. The choice of whether to use carbon adsorption or an afterburner for the emissions control device depends upon specific emissions limitations criteria for the site, as well as concerns over the potential for formation and emission of undesirable air pollutants.

At similar sites where control specifications were more rigorous, a 15 ton/hour indirect fired unit has been used with a conservatively designed and operated afterburner. On multiple sites contaminated by PCB's, indirectly heated thermal desorbers have been used with secondary condensation and carbon recovery type gas systems. Table 1-1 Examples of Full Scale Thermal Desorption Experience for Chlorinated Hydrocarbons presents a partial list of full scale experience for thermal desorption units operating on materials impacted by chlorinated organic chemicals.

Considerably less experience exists for the application of thermal desorbers to radioactive/hazardous mixed wastes. Approximately four small scale projects have been completed outside of the laboratory with varying degrees of success. The removal of a hazardous constituent from a solid matrix is a straightforward extension of the prior work done and has been successfully transferred to mixed waste operations. However, residuals management and emission issues posed by radioactive materials are significant and require a specialized approach within the general context of thermal desorption. Highly successful pilot studies have been performed, demonstrating that all mixed waste issues can be addressed, and these results are ready for transfer to full scale operations.

With regard to the application of thermal desorbers to mixed hazardous and radioactive waste, these units are almost without exception indirect fired, because the control of large volumes of gas to remove radioactive materials can be prohibitively expensive. By using indirect fired units, economical production capacity can be achieved simultaneously with complete control of the radioactive air emissions. Three small solvent contaminated sites have been treated with indirect heated units having condenser, carbon and high efficiency particulate (HEPA) filters for emissions

[9] Giese, June 23, 1992.

control. Radioactivity levels were extremely low in two of these sites, minimizing issues related to radioactive materials control. Another small site with mercury and radioactivity was treated with excellent removal of the mercury from the solids. However, mixed waste residuals were generated from the emission control system, resulting in ongoing mixed waste storage and preventing complete closure of the site. Pilot testing has been conducted on multiple materials with significant radioactivity levels resulting in separation below measurable levels of the hazardous and radioactive constituents.

TABLE 1-1. Examples of Full Scale Thermal Desorption Experience for Chlorinated Hydrocarbons

UNIT	CONTAMINANTS	STATE	TONNAGE
Indirect fired Thermal Desorption Unit (TDU) with condenser and carbon	PCB PCB PCB PCB PCB Organochlorine pesticides Chloraniline derivative Organochlorine pesticides Perchloroethylene (PCE) Chlorobenzene TCE, Dichloroethene (DCE) Pesticides TCE TCE, Dichloroethane (DCA)	MA SC NY IL KY OH MI NC NY NJ PA ID NC CA	50,000 60,000 42,000 13,000 20,400 19,000 8,000 19,000 2,000 6,500 18,000 500 12,000 3,000
Indirect fired TDU with afterburner	TCE	OK	1,000
Direct fired TDU with condenser and carbon	Chlorinated Solvents Chlorinated Solvents Chlorinated Solvents Chlorinated Solvents Chlorinated Solvents Organochlorine pesticides	ME NH NJ MA NJ AZ	18,000 8,000 18,000 6,500 4,400 50,000
Direct fired TDU with afterburner	Chlorinated Solvents Organochlorine pesticides Organochlorine pesticides Volatile organic compounds (VOCs) VOCs DDT	NJ FL FL PA NY GA	6,500 5,200 2,200 28,000 6,500 3,000

	TCE, PCE Pesticides	NY WA	18,000 14,000

Adapted from Cudahay and Troxler (1993) with additional data from public domain literature.

These studies used an indirect heated unit with condensation, carbon and HEPA filtration; and products and residuals have been (or can be) disposed from these pilot studies.

Mixed waste operations have been performed at full and pilot scale with uranium, plutonium, mixed fission products, and activation products as radioactive contaminants. These materials exist mostly as metals, metallic oxides or salts. The radionuclide tritium, however, exists principally as "heavy" water and poses significant radioactive migration issues for thermal desorbers when other volatile hazardous constituents require removal from the solid matrix. High levels of tritium have been documented in only one pilot study. The liquid residual from this test had significant radioactivity and could not be effectively managed because of it. Further liquid-liquid separation or alterative treatment of the liquids would be required to achieve a complete solution in this application.

A number of treatability studies on mercury contaminated mixed wastes have been conducted at Oak Ridge, Tennessee and elsewhere with results indicating considerable promise for this technology. However, large scale applications are still largely in the planning stages [10]. A number of commercial vendors have been identified with varying interests, capabilities and facilities that might be applicable to the thermal desorption of mixed wastes [11]. It is anticipated that this remediation will be performed to the satisfaction of the Land Disposal Regulations (LDR) and local agreements such as the Federal Facilities Compliance Act. The LDR treatment requirement for high-mercury wastes, that fail TCLP or are specifically listed for mercury, is that they be thermally treated to reduce the residual concentration to below 260 ppm. The resulting treated product must then exhibit a Toxicity Characteristic Leaching Procedure (TCLP) test result which meets the LDR UTS. At this time the standard is less than 0.2 mg/l Hg.[12]

1.10 The Need for Flexibility and Variances for Technical Guidelines

The LTTD group recognizes that on some sites, states may choose to go beyond these guidelines. It is the responsibility of operators to find out from regulators whether specific state requirements are applicable; and it is in the states' best interest to allow variances from these technical guidelines,

[10] Krabill and Shippy, Y/DZ 1182, April 1996.

[11] Baker, et. .al., Y/DZ 1029, July 1993.

[12] Krabill and Shippy, Y/DZ 1173, April 1996

based on specific technology applications. Variances also should be considered to allow for the use of appropriate alternative sampling or analytical methods.

In order to provide flexibility in these technical guidelines, variances for alternate sampling, analytical, or monitoring methods may be appropriate if:

1. The method has previously been used successfully under similar site conditions, as documented by a regulatory agency; or

2. The method has been tested successfully by an independent, nonregulatory verification entity; or

3. The method is approved by the agency, based upon site specific conditions or technology modifications; the following criteria should be considered:

    a. <u>waste stream homogeneity</u> (e.g., verification sample frequency could be decreased for a homogeneous waste stream where large volumes of material are to be treated and increased for a heterogenous waste stream);

    b. <u>contaminant concentration in waste stream</u> (e.g., verification sample frequency could be decreased for a waste stream that is uniformly contaminated);

    c. <u>automatic feed cutoff/ shutdown conditions</u> (e.g., shutdown condition based on exit temperature could be modified based on a higher verification sample frequency);

    d. <u>receptor proximity</u> (e.g., fugitive dust control requirements could be relaxed based on receptor proximity).

1.11 The Need for Public Involvement

Studies of low temperature thermal treatment systems have been motivated in part by tribal and stakeholder concerns. Tribal and stakeholder representatives on many occasions in a variety of arenas have expressed a desire for alternatives to conventional incineration methods. In particular, they would like to see systems which generate less air pollution and which reduce risks to the environment and to public health, based on comparisons of data with those of established incinerator methods. In certain situations LTTD systems may fulfill this need.

The LTTD Work Team recognizes the need for stakeholder involvement when selecting new technologies for the cleanup of contaminated sites. In keeping with the full ITRC, they have adopted the concepts in principal put forward in "A Guide to Tribal and Community Involvement in Innovative Technology Assessment," developed by the participants of the DOIT Tribal and Public Forum on Technology and Public Acceptance. This guide clearly points out the desire and need for "meaningful community involvement," which includes the opportunity to comment, at the site implementation level.

Although emphasis is placed on public and tribal involvement at the site specific level, technology developers need to be aware of the types of information the community will require for their decision making process. The guide can be used as a "checklist" by technology developers and regulators. Examples of concerns which are global rather than site specific include noise levels, air emissions, risk to the public, permanence of the remedy and cost. Of particular importance to tribes and stakeholders is access to comparative emissions and operational data for new technologies versus conventional technologies.

In addition to concerns about the environment and public health, some tribal members have raised general cultural and spiritual concerns. For instance, technologies which pollute the air may be offensive to certain Native American religions and may interfere with traditional religious practices. Also, the transport of contaminants such as mercury or radionuclides into rivers can subvert river rights guaranteed by treaty to certain Native American tribes. A technology which addresses this problem could therefore have a positive cultural impact. When new technologies are evaluated, tribes and stakeholders should be given the opportunity to comment on the potential cultural impact, which could be positive or negative, of that technology.

1.12 Cost and Performance Reporting Guidelines

The ITRC has adopted the "Guide to Documenting Cost and Performance for Remediation Projects," developed by the Federal Remediation Technologies Roundtable, as a model to standardize cost and performance reporting. The LTTD group further recommends that the data and information found in the EPA Cost and Performance Report for the TH Agriculture & Nutrition Company Superfund Site is appropriate for use in documenting applications of thermal desorption. Routine applications of thermal desorption may not need to be documented using the cost and performance format. The EPA Technology Innovation Office has agreed to determine which thermal desorption applications need to be documented using the cost and performance format. A standardized outline of a cost and performance report for thermal desorption is provided in Appendix B of this report.

2.0 PRETREATMENT SAMPLING

2.1 Sample Parameters and Analytical Methods

For purposes of this document, the objective of pretreatment sampling is to adequately test the waste and describe the waste to provide the expected range of contamination on the site. This information is necessary in order to select the appropriate waste (e.g., soil) for the thermal treatment test runs and to ensure that the most heavily contaminated and most difficult to treat. samples are selected for the test run. It is assumed that the site has been adequately characterized during a remedial investigation. Therefore, sample frequency guidelines are not addressed in this document.

Pretreatment sampling for solid media and mixed waste contaminated with mercury and/or hazardous chlorinated organics should include the parameters for the contaminant source outlined in Table 2-1. Pretreatment sampling parameters should also include any additional contaminants of concern associated with the waste. (See Section 3. Feed Soil Limitations for special considerations regarding soil). Sample data collected during an investigation of the site may be substituted for the following guidelines, as appropriate.

EPA/American Society of Testing and Materials (ASTM) methodologies should be utilized for all parameters. Recommended methods for the various sampling parameters are also presented in Table 2-1.

TABLE 2-1. Sampling Parameters for Thermal Desorption Treatment of Solid Media and Mixed Waste Contaminated with Mercury and/or Hazardous Chlorinated Organics

CONTAMINANT	ANALYTICAL PARAMETERS	ANALYTICAL METHOD
Total Petroleum Hydrocarbons (TPHC)	TPHC	· SW-846 Method 8015B
or Total Recoverable Petroleum Hydrocarbons (TRPH)	TRPH	· EPA Method 418.1
Chlorinated Pesticides	Organochlorine Pesticides and PCBs [1]	· SW-846 Method 8080 Gas Chromatograph/ Electron Capture Detector (GC/ECD)
	Semivolatile Organics (BNAs) [2]	· SW-846 Method 8270 Gas Chromatograph/Mass Spectrometer (GC/MS)
Polychlorinated Biphenyls	Organochlorine Pesticides and PCBs	· SW-846 Method 8080 (GC/ECD)
	Semivolatile Organics [2]	· SW-846 Method 8270 (GC/MS)
Chlorinated Solvents	Volatile Organics [3]	· SW-846 Method 8240 (Packed Column) · SW-846 Method 8260 (Capillary Column)
	Semivolatile Organics [2]	· SW-846 Method 8270 (GC/MS)
Mercury	Total Mercury TCLP Mercury	· SW846 7471 · SW846 1311 & 7471
Radionuclides [4]	alpha (α) and beta (β)	· gross alpha (α) and beta (β)

Table Footnotes

1. Both SW-846 methods 8080 and 8270 can be used for PCBs and pesticides. Method 8080 achieves lower detection limits and is cheaper than method 8270; however, method 8270 may be preferred if other semivolatile organic contaminants (e.g., polycyclic aromatic hydrocarbons) are present in the source material. Although either method is suitable for pretreatment soil analyses, method 8080 is recommended for treatment verification analyses since lower detection limits are achievable.
2. BNA compounds are base/neutral/acid extractables. This includes polycyclic aromatic hydrocarbon (PAH) compounds.
3. EPA target compound list volatile organic (VO) or priority pollutant VO scans including xylene with a gas chromatograph/ mass spectrometer (GC/MS) library search for the ten highest peaks.
4. In some cases, isotopic analysis may be required. Site knowledge can be used to determine whether such analysis is appropriate. (Note: gamma isotopes are counted with beta.)

Pretreatment sampling and analysis of mixed waste can generate more mixed waste, which is an undesirable result. Therefore, when dealing with mixed waste, it is appropriate to develop a sample management plan. The plan should detail the disposition of all samples and include pretreatment, in process, and closure. This will allow the processor to deal proactively with the waste minimization issues related to analytical residues.

Attempts should be made to minimize the number of analyses required. Furthermore, when an analysis must be performed, there are certain points of EPA doctrine which help to minimize these issues. The two most significant of these are the RCRA lab sample exclusion and onsite treatment at the lab. The sample exclusion states that a hazardous waste sample is not regulated as RCRA waste while at an analytical laboratory for the purpose of characterization. Consequently, analytical residues derived from listed waste (i.e., “F,” “P,” “U” and “K” waste codes) are not, themselves, listed wastes. They may exhibit hazardous characteristics and still be regulated under RCRA, but that issue is addressed by the next method.

Analytical laboratory waste generators can perform onsite treatment to eliminate hazardous characteristics (i.e., “D” codes) by developing a RCRA compliant treatment protocol (neutralization for corrosives, stabilization for toxic metals), preparing a Waste Analysis Plan (WAP) describing it, and submitting the WAP to the RCRA implementing agency for review and approval. Approval is normally signified by receiving no comments from the agency within the RCRA specified 30-day agency review period, after which onsite treatment can be initiated according to the WAP. Using one or both of the above-mentioned methods, analytical residues from mixed waste samples often can be rendered as only low level radioactive waste and disposed accordingly. In any event, planning for mixed waste treatment projects must include addressing waste management issues relative to analytical residues.

2.2 Sample Quality Assurance/Quality Control (QA/QC)

All QA/QC required by the specified sampling and analytical methods shall be completed. Lab QA/QC summary documentation (including nonconformance summary report[13] and chain of

[13] using standard Contract Laboratory Program (CLP) format or equivalent

custody) should be submitted with analytical results. Full QA/QC deliverables as specified by the analytical method should be maintained and should be available upon request for at least three years. Ultimate responsibility for QA/QC documentation belongs with the responsible party of a site or the vendor conducting a demonstration. However, the responsible party may contract with another entity, such as an analytical laboratory, to house the actual QA/QC data.

3.0 FEED SOIL LIMITATIONS

The generator of the soil shall certify, based upon site history or previous sampling/characterization, the nature of the material to be treated. If there is any doubt as to the nature of constituents, sampling shall be required. Soil contaminated with elevated levels of heavy metals shall not be treated unless the emission rate and impact of those metals has been evaluated and found acceptable by the approving authority.

The soil conditions listed below should require pretreatment or a test run to ensure the technology will be effective.

1. soil moisture >35%[14]
2. material > 2" diameter[15]
3. soil has high plasticity [16]
4. soil has high humus content [12]
5. greater than 25% (lower explosive limit) LEL in gas in desorption chamber [17]
6. for mixed waste, these technical guidelines are appropriate only for contact handleable, low surface dose, non-volatile radioactive materials that are less than 100 nanocuries TRU per gram and are within radioactivity levels that meet containment structure controls[18]

[14] When dealing with mixed waste, it is important to note that moisture content of soil can degrade/impede the accuracy of the alpha/beta scans. The inherent limitations of the radionuclide monitoring instruments must be considered when establishing limits on moisture content.

[15] Maximum size of treatable material may be a function of equipment.

[16] The value will be regarded as "high" if the plasticity or humus content is significant enough to impact the efficiency of the treatment unit.

[17] Limitation is included to address explosivity and is not applicable for inert environments. USEPA, November 1993 indicates level of concern is 100,000 ppm for total organic carbon.

[18] The following conditions are beyond the scope of this technical requirements document and require more detailed review of radiation issues: TRU isotopes > 100 nCi/g, radioactivity levels exceeding specific building or containment structure limitations, the presence of tritium (H-3) or carbon-14, radiation dose rates exceeding contact handleable levels (i.e., greater than 1- 10 mR/hr at 1 meter).

Either an on-site test run or a representative test run conducted at another site will be deemed sufficient to meet this guideline. For batch units, feed requirements may be less stringent.

4.0 TREATMENT VERIFICATION SAMPLING

4.1 Sample Parameters

Treatment verification sampling for solid media and mixed waste contaminated with mercury and/or hazardous chlorinated organics should include applicable parameters outlined in Table 2-1. In addition, any other site specific contaminants of concern for the treated material should be included in the parameter list. Verification sampling is not required for any contaminants which will be unaffected by thermal treatment, including metals.

For LLMW, both the process residuals (e.g., condensate) and air emissions should be routinely sampled and analyzed for radioactivity. It is normally not required to analyze the treated solids for radiation levels as a part of process verification. It is recommended that treated solids be monitored for radiation levels only as necessary for health and safety reasons or to confirm compliance with disposal site acceptance criteria. This requirement is normally detailed in the site or project specific work plans, but this should preferably be done with a direct measurement technique in order to eliminate the generation of radioactive analytical residuals that may also be mixed waste.

4.2 Sample Frequency

For soils, post-treatment soil sampling for full scale operations will require one (1) composite sample for each one hundred (100) cubic yards or one hundred and forty (140) tons of treated soil, using method ASTMC702-87. Each composite should comprise five (5) discrete samples. As an alternative to composite samples, five (5) discrete samples for each one hundred (100) cubic yards or one hundred and forty (140) tons of treated soil may be collected. For batch mercury operations on the order of one to 20 tons, one composite sample event for mercury is required per batch.

Based upon documented efficiency of the treatment system, the post-treatment sample frequency may be reduced on a case by case basis. This situation may be particularly applicable to situations where the waste is homogeneous and large volumes of waste are to be treated. Special consideration is required for volatile organics sampling.

To minimize loss of volatile contaminants, it may be appropriate to collect volatile samples using specialized sampling techniques such as the sampling method recommended by the state of Illinois[19], the methanol preservation method soon to be adopted by the state of New Jersey[20], or EPA Method

[19] Dragovich, 1997.

[20] Sogorka, 1997.

5035 for the collection and extraction of soil samples for volatile organics[21]. For sampling during a proof of process performance test, see Section 7.1

When dealing with mixed waste, proactive measures should be taken to avoid the creation of additional similar waste. Discretion on quantities, types of sampling, and when to sample cannot be over emphasized. Timing can mean the difference in dispositioning the samples with the bulk of the treated waste or added cost of dispositioning and tracking the residuals separately. For LLMW, the minimum radioactivity sampling frequency should be:

- weekly for process residuals and air emissions,
- after each maintenance activity on a radioactivity APC device, and
- daily/shift swipe samples of controlled surface contamination areas (CSCA's).

4.3 Analytical Methods

The EPA/ASTM methodologies for hazardous constituents presented in Table 2-1 should be used. For verification sampling, gas chromatography methods with a mass spectrometer detector system are required for analysis of volatile/semivolatile contaminants. For hazardous waste, mass spectrometer methods are not required if the following conditions are met.

1. Contaminant identity is known;
2. the contaminant chromatographic peak is adequately resolved from any other peak; and
3. at least 10% of the sample analyses (minimum of one sample) are confirmed using the appropriate gas chromatograph/mass spectrometer detection system.

4.4 Sample QA/QC

All QA/QC required by the specified sampling and analytical methods should be completed. Lab QA/QC summary documentation, including nonconformance summary report and chain of custody, should be submitted with analytical results. Additional minimum requirements should be specified in the test plan, work plan and site specific QA/QC plan. Demonstration tests require a higher level

[21] This method requires placing a 5 gram sample, weighed in the field at the time of collection, in a pre-weighed vial with a septum-sealed screw-cap that already contains a stirring bar and a sodium bisulfate preservative solution. The vial is sealed and never opened again.

of accuracy, such as that provided by the Contract Laboratory Program (CLP). For proof of process testing guidelines, see Section 7.1.

Full QA/QC deliverables shall be maintained and should be available upon request for at least three years. Ultimate responsibility for QA/QC documentation belongs with the responsible party of a site or the vendor conducting a demonstration. However, the responsible party may contract with another entity, such as an analytical laboratory, to house the actual QA/QC data.

5.0 SOIL/WASTE HANDLING AND STOCKPILING

Pretreatment soil stockpiles shall be stored on a surface such as concrete or an impermeable liner of appropriate thickness for the contaminants of concern. To minimize volatile emissions and protect worker safety, the stockpile should be covered (e.g., by a secured plastic cover of appropriate thickness or equally effective spray coating) and may be stored within the confines of a building. At a minimum, the staging area for the stockpiles should be constructed to prevent surface water and precipitation from entering the area and to collect leachate. All soil stockpiles should remain covered to prevent the generation of dust. For hazardous waste, water spray or equivalent should be utilized as necessary to prevent dust generation. In the case of mixed waste, addition of water to prevent dust artificially adjusts the measured radiation dose rate at the surface of the material, which is a parameter of interest. Therefore water quantities added to the waste should be controlled and logged. Monitoring should be provided to ensure that unacceptable levels of dust generated from the movement and handling of soil do not migrate from the site.

If the material to be treated is regulated as a hazardous waste or debris, then it must be stored in accordance with 40 CFR 264 or 265 or state equivalent, addressing interim status. These requirements include land disposal restrictions (LDR), minimum technology requirements, and corrective action management unit (CAMU) requirements.

Post-treatment soil should be stored in the same manner as pretreated soil until analytical testing has confirmed that the soil has successfully been treated. A physical barrier, such as a curb or a wall, should be maintained to separate the pretreatment from the post-treatment stockpiles. All areas should be restored, to the extent practicable, to preremediation conditions with respect to topography, hydrology and vegetation, unless an alternate restoration plan is approved by the governing agency.

Both mercury (retort) and LLMW treatment units typically manage much smaller volumes of contaminated media and debris. These are often managed in containers such as drums or boxes. At times small waste piles are utilized, but only with meticulous controls on fugitive emissions. Material is moved from a feed staging area to the feed preparation and/or treatment area. After treatment, material is placed in new or appropriately decontaminated/recertified waste containers while post treatment sampling results are obtained. Material that meets specification is then shipped to permitted storage or disposal facilities. The use of containers for many of these steps warrants requirements on container identification and management so that both accountability for materials

is achieved, and the integrity of the container vessel is maintained to prevent leakage. One generator has found that the use of tamper proof seals and bar coding can eliminate disposal site concerns regarding container traceability and the need to further sample material that has already been characterized.[22] RCRA standards for container management are lengthy and can pose administrative and compliance issues for remedial projects. None-the-less, project plans should address them in order to achieve substantive compliance.

6.0 SYSTEM OPERATING GUIDELINES

6.1 Primary Unit Operations

The unit shall be operated within the operating envelope created during site specific test runs conducted to optimize system performance. Operating conditions such as temperature range, residence time and airflow in primary units and air pollution control devices should be determined during the test runs. Proof of performance (POP) testing shall consist of three runs for each condition.

The test shall be conducted for the worst case contaminant conditions at the maximum processing rate. If conditions dictate (e.g., wide variation in soil type on site), this test may include separate runs for treatment of differing soil types or media contaminated with hazardous or mixed waste. For example, if soil is contaminated with chlorinated solvents, two runs could be required: one with coarse soil and one with fine soil. If any adverse feed soil conditions as listed in Section 3.0 (e.g., high moisture content, high plasticity) exist, soils exhibiting these conditions should be treated during an appropriate number of test runs.

The use of non-radioactive surrogate media to test the unit for operational readiness is strongly recommended prior to treating mixed waste. A system operations plan should test the overall range for the unit, the integrity of the chamber and the ancillary equipment. Cooling and heating lines should be inspected before and after the test runs. Seals should be cleaned and inspected before and after each run. Prior to actual treatment of contaminated material, the containment units/structures should be inspected for soundness. Monitoring instrumentation should be regularly tested, certified, maintained and repaired or replaced in accordance with both manufacturer's recommendations and EPA test method requirements.

[22] State of Idaho DEQ, December 23, 1993.

Test runs at each new site are generally expected, unless a previous site having similar media characteristics, the same constituents of concern, and similar contaminant levels has been successfully remediated, using the same type of equipment. See Section 7.1 for stack testing guidelines.

6.2 Air Emission Control Unit Operations

When treating hazardous waste, an effective air pollution control system is required in order to ensure adequate hydrocarbon, acid gas and volatile contaminant control. To ensure adequate particulate control, a baghouse or equally effective air pollution control device is required. Acid gases may be controlled by using a wet or dry scrubber or by using a coated baghouse. Operating conditions, such as temperature and duration, for air pollution control devices will be determined during the test run, subject to individual state approval.

For the particular case of mercury impacted media, special control devices will need to be considered and implemented as part of the over all air emission control system. The devices will need to have the ability to remove the mercury species present in the vapor. Normally this will involve a combination of filters, acid scrubbing and sulfonated carbon treatment.

Mercury concentrates and contaminated media from air emission control systems must be handled appropriately. All residues, condensates, scrubber solutions, filter media, etc., should be managed with ultimate disposal or reuse as the end objective. Amalgamation is generally used for mercury concentrates that cannot be recycled. Sizing, blending and treatment of contaminated emission control media with the incoming waste stream is recommended where possible. Encapsulation is an alternative for debris waste generated, such as filter media. Solutions will need to be filtered and the mercury removed prior to discharge.

For units that are managing LLMW, the gas treatment system should employ two HEPA filters in series (i.e., redundant HEPA filters) that have been tested to demonstrate their efficiency in the installed configuration (i.e., DOP testing or equivalent). Prior to each waste material being fed to the unit, calculations should be made to verify that at the demonstrated control efficiency of the unit, radioactive emissions will not exceed 0.1 mR/yr to the general public, and will be in compliance with the NRC standards for the maximum permissible concentrations of specific radionuclides in emissions to air.

For mixed waste operations, Selective Ambient Air Monitors (SAAMs) should be positioned to provide maximum, continuous air monitoring and information for radiation protection purposes. Alternatively, monitoring by frequent routine air samples with immediate radiation counting of the filters is acceptable. Suggested locations are near treatment units, near treatment piles, near excavation activities, and in final emission streams from filters.

6.3 Monitoring of Operating Parameters

At a minimum, the following operating parameters should be monitored and recorded during operation of the unit:

1. exit treated waste temperature
2. desorber pressure and pressure drop associated with emission control
3. waste feed rate or batch load
4. afterburner temperature (if applicable)
   NOTE: afterburners should not be used in Hg treatment operations
5. exit gas temperature from the desorption chamber (if applicable)
6. an indicator of stack gas velocity and temperature (if applicable)
7. flow rate and pH of acid gas scrubber liquor
8. ambient air monitored by SAAMs (for radionuclides)

Monitoring of the soil outlet temperature of thermal desorption units is routinely used as a surrogate for the operating envelope. Although the monitoring may not be absolutely accurate, if the monitored outlet temperature is the same as that measured during an acceptable performance test, there is confidence that the soil has been remediated to the required treatment level. The temperature monitoring is backed up by outlet soil sampling whose frequency has been reduced because of the monitoring. The requirement for monitoring soil outlet temperature is not related to air emissions; however, an automatic waste feed cutoff is appropriate to prevent significant quantities of soil from needing to be retreated. Other operating parameters may be required as a result of site, waste stream, and equipment specific conditions.

6.4 Automatic Waste Feed Cutoff /Shutdown Provisions

For continuous feed units treating organic hazardous or mixed waste, the conditions shown in Table 6-1 shall trigger automatic shutdown of contaminated feed. For batch units, the conditions shown in Table 6-1 shall trigger shutdown procedures for the unit. However, other automatic waste feed cutoff/ shutdown provisions may be added on a case by case basis, considering equipment design and contaminants of concern.

Table 6-1. Automatic Waste Feed/Shutdown Conditions and Provisions

Conditions		Initiation of Waste Feed Cutoff/Shutdown
1	Primary burner or heating system failure	Instantaneous
2	Outlet waste temperature below set point which is based on type and amount of contamination, waste type, and test run	10 minute delay
3	Afterburner temperature (if applicable) below set point used in test run	30 second to 2 minute delay

4	Blower failure or positive pressure at the desorber	Instantaneous
5	Bag house pressure drop[1], venturi pressure drop, or drop in liquid/ gas ratio (if applicable) outside the operating envelope determined during test run.	Instantaneous
6	Carbon monoxide in exhaust gas (for units w/ afterburner only)	10 minute delay
7	Waste feed rate exceeds approved limit	10 minute delay
8	An appropriate indicator of significant change outside the operating parameter for gas velocity through secondary treatment device	10 minute delay
9	Local SAAM Annunciation (for radionuclides)	10 minute delay

Table Footnotes
1. For batch fed units pressure drop will trigger shutdown of unit.

For treatment of mercury/mixed waste where there are no organics, a significant difference exists. In this case, the goal of operation of the thermal desorber unit is to achieve Land Disposal Restrictions (LDR). Faulty operation and poor performance may only require rerunning the treatment since the ultimate test of a good run is in measurement of the treated material.

Shutdown conditions for treatment of mercury contaminated media include:

1. heating system failure,
2. positive pressure at desorber, and
3. indication of failure or bypass of emission control equipment.

6.5 Fugitive Emissions Control

Fugitive emissions control is required and shall be accomplished by maintaining negative pressure in equipment designed to operate at negative pressure. Controls to limit fugitive dust emissions at the treated waste outlet shall be in place. Treated waste should be moisturized within the enclosed discharge conveyor to minimize dust generation. Emissions of particulates and volatile organics should be minimized through engineering controls and appropriate handling practices.

Clean Air Act regulations 40 CFR 61, Subpart H Radionuclide National Emission Standards for Hazardous Air Pollutants (RADNESHAPS) govern radionuclide emission from facilities. In new operations at non-DOE facilities, the RADNESHAPS permit is granted by a State agency rather than the USEPA, following the same standards as imposed by USEPA. Any new source of radionuclide air emissions must be approved by the EPA before operations commence, unless specific exemption limits are met (i.e., <0.1 mR/yr for the unit or <1 mR/yr for the facility). Information obtained through process knowledge can be input into computer programs which can calculate the expected emissions, and indicate whether the calculated results will meet the required standards for the

species. Secondary containment and negative pressure units facilitate the meeting of these requirements.

6.6 Radioactive (Mixed Waste) Materials Treatment Units

Considering the nature of radioactive materials (RAM) and the importance of protecting workers and the environment from the impacts of their release from the treatment unit, design and operating standards for these units are necessarily very stringent. These standards are summarized here, with emphasis given to their impact on the use of thermal desorption units.

The focus of the design and construction standards for RAM processing units is to assure that the RAM is contained within the unit and does not leak into the work space or the environment. The primary treatment unit is designed and constructed to the manufacturer's standard specifications. The tank systems should be designed and constructed to American Society of Mechanical Engineers (ASME), American Petroleum Institute (API) or American Water Works Association (AWWA) tank codes. The liquid systems should be welded or flanged to the maximum extent practicable. Threaded pipe connections should be limited to instruments and similar service where welds or flanges are not normally used. Prior to initiating RAM operations, or after significant maintenance, liquid systems should be hydrostatically tested to assure the absence of leakage. Also, prior to RAM operations, it is strongly recommended to perform hot functional testing at maximum operating temperature using non-RAM feed to assure adequate, leak free operation of the unit. This greatly simplifies both repair of leakage and the cleanup of any spilled fluids. This also applies to non-RAM portions of the unit such as heat transfer fluids that if spilled could mix with RAM after startup and cause large volumes of secondary waste to be generated.

Secondary containment shall be provided for all hazardous and/or radioactive liquids stored in tank systems. As a minimum, the containment system shall provide for 100% of the capacity of the largest tank within its boundary. The system shall be designed to prevent run-on/runoff or infiltration of precipitation into the containment system, unless the system has sufficient excess capacity to contain run-on or infiltration[23]. For PCBs, the requirement is 200% of the largest tank or 25% of the total, whichever is greater. The piping systems that serve the thermal desorption system and contain hazardous and/or radioactive fluids, but are not installed within the containment, shall be inspected for leaks daily. These shall either be repaired or taken out of service within 24 hours of detection of a leak.

The material handling system should be designed to totally contain the waste material. This includes the feed preparation, feed system, primary treatment unit, and treated solids handling systems. Transfer from/to containers and/or sealed hoppers, completely sealed equipment, and maintaining internal pressures below atmospheric are the most effective containment techniques. Leakage of even minor amounts of dust can cause significant operational and environmental problems.

[23] 40 CFR 264 Subpart J

A Safety Analysis Review (SAR) shall conducted to evaluate the impact of a release of the radioactive inventory from the treatment unit during possible events such as over pressurization, breach of the primary containment vessel, loss of electric power, etc. If this analysis shows that unacceptable radiation dose consequence to the public exists from this release, then an appropriate engineered secondary containment structure shall be erected around the primary unit. These issues are thoroughly addressed in the USNRC regulations and/or DOE Orders that govern accident analysis for radioactive materials facilities. Many radioactive waste processing facilities are constructed inside buildings with concrete foundations, HEPA filtered general ventilation systems and backup power supplies to prevent accidental release of radioactive materials. Seismic rated facilities are not generally required for low level radioactive waste facilities[24]**.**

7.0 PERFORMANCE TEST AND AIR EMISSIONS MONITORING GUIDELINES

From a state's point of view, performance tests results and air emissions levels are major factors in determining whether a process will operate in a manner that is protective of human health and the environment and whether that process can be permitted. This section will focus on performance test guidelines, emissions monitoring guidelines, frequency of monitoring and parameters. Different approaches are needed for treatment of media contaminated with chlorinated organics vs. mercury vs. radioactive mixed waste. Air emissions criteria are not addressed because these are determined by individual states.

7.1 Proof of Process Performance (POP) Testing for Air Pollution Control Systems

7.1.1 Units Treating Media Contaminated with Chlorinated Organics

For units treating media contaminated with chlorinated organics, the minimum control efficiency of the air pollution control system is a technology driven requirement (i.e., what a well-designed, well-operated, well-maintained system will provide.) The measurement of this efficiency has traditionally been in terms of destruction/removal efficiency (DRE) which is defined as the ratio of the amount of contaminant prevented from being released through the stack compared to the amount of contaminant in the feed.
For purposes of this document,

[24] The source of these requirements is primarily from NRC reg. guide 1.143 (Radwaste System Design and Operation) and 10 CFR 50.59 (safety reviews).

$$\text{DRE} = \frac{\text{Mass of waste IN feed - Mass of waste OUT (at stack)}}{\text{Mass of waste IN feed}} \times 100$$

(% Destruction/Removal Efficiency)

In many cases, the stack emissions after the application of air pollution control equipment are nondetectable. The standard way to deal with this problem is to assume emissions at the detection limit. Unfortunately, the resulting DRE is frequently less than 99.99 % because of a relatively low contaminant input rate. The remedy for this problem has been to spike the untreated waste with contaminants. The concept of adding contamination to the waste to be treated is discouraged for the purposes of this document unless an appropriate nonhazardous surrogate is used, especially since the volume of contaminant used in spiking could exceed the total amount of contamination to be treated.

Therefore, proof of process tests with DREs less than 99.99 % will be deemed acceptable, provided that air contaminants during the demonstration tests are nondetectable using detection limits approved in the demonstration testing program. However, a good faith effort should be used in locating the most contaminated waste. We believe this will satisfy the requirement to prevent releases of hazardous constituents to the air which might pose a threat to human health and the environment as required by 40 CFR 264 Subpart X. The process operating parameters recorded during the demonstration test should become the operating limits for the equipment.

It should be noted that even if the technology meets the minimum technology guidelines presented in this document, states in conjunction with community stakeholders will still require an impact assessment before allowing the unit to be permitted.

A performance test should include sampling and analysis of untreated and treated waste and treatment residuals, such as air pollution control residuals. Sampling of treated and untreated waste and residuals should be concurrent with stack testing (See Section 7.3). Where creation of products of incomplete combustion (PICs) or existence of dioxins/furans is of concern, analysis of dioxins/furans should be considered for all soils and treatment residuals.

Hydrochloric acid emissions must be limited to no more than four pounds per hour or, for emissions exceeding four pounds per hour, removal efficiency at the air pollution control device shall be a minimum of 99%. Particulate matter must not exceed 0.08 grains per dry standard cubic foot, when corrected for the amount of oxygen in the stack gas.

7.1.2 Units Treating Media Contaminated with Mercury

No technology-based requirements for mercury emissions currently exist. Allowable mercury emissions would be based upon site by site review and specific state regulations and air emissions testing would be required to demonstrate compliance within these limits.

For mercury treatment processes, the measure of process efficiency is based on the ratio of total mercury before treatment vs. total mercury after treatment. Final waste must be below treatment standard for LDR.

7.1.3 Units Treating Media Contaminated with Mixed Waste

For mixed waste, see section 6.5 for discussion on fugitive emissions control as required by regulation. See 7.3 below for stack testing.

For mixed waste facilities, the feed to stack decontamination factor (DF) should be determined for the unit. This is the ratio of the amount of radioactivity (in curies) that is present in the feed to the amount in the air emission. Using this measure, high DFs on the order of 10,000 or more are good and desirable. This is the underlying parameter to verify compliance with EPA and NRC limitations on dose to the general public. In some cases, it may be necessary to determine radionuclide specific DFs. Using these demonstrated DFs and an appropriate dose model, limitations can then be developed for the maximum allowable radioactivity in the feed material. Alternatively, it is acceptable to demonstrate no detectible radioactivity in the air emission, provided that the maximum radioactivity for the feed material is used for the POP test, and that the detection limits for the radionuclides are less than NRC specifications for laboratory minimum detection limits (MDLs). Much more so than for organic compounds, the physical and chemical form of the material is important for the POP test. Radioactive metals (large chunks) and oxides (fine powders) may behave very differently in a treatment unit. Chlorides can significantly alter the Cesium-137 DF for high temperature units. If variability of these or similar treatment unit specific parameters exists at the site, multiple POP test runs are recommended, using worst case media from each material type.

It is common to achieve low DFs for either tritium (H-3) or carbon-14. Both of these isotopes are normally present in highly mobile forms in radioactive materials (i.e., tritium in water, and carbon-14 in either organic chemicals or carbon dioxide). This is acceptable, in that their emission to air at reasonable levels is accepted and approved by NRC in their standards for protection against radiation (10 CFR 20). Both isotopes have low dose impacts to the public. The essential aspect of both is to recognize and quantify their presence prior to treatment and determine that their emission rate (both concentration and dose impact) is within NRC standards. A POP test should verify this, either directly by gas sampling, or indirectly by mass balance and calculation.

7.2 Proof of Process Performance Testing for Units Treating Contaminated Media

Proof of process performance testing shall consist of three runs for each condition. For semi-volatiles, compositing of periodic grab samples consistent with the process is acceptable. There should be a minimum of one soil/media composite sample per each test run. For batch operations such as mercury retort, sample before and after each batch. Special consideration is required for volatile organics sampling. When appropriate, volatile samples should be collected using specialized sampling techniques (see Section 4.2) to minimize loss of volatile contaminants.

Media cleanup levels are determined on a site by site basis, as determined by the state or federal regulations. For example, containerized waste generated under RCRA would typically need to meet LDR standards. The source of the waste (CERCLA vs. RCRA) will help determine the treatment standard.

It is recommended that the POP test also include an assessment of the acceptability for permanent disposal of all process residuals and secondary wastes. This is especially important for mercury and mixed waste treatment projects, because little or no disposal capacity may exist for these materials. The waste acceptance criteria (WAC) for potential TSD facilities should be reviewed. Unless generator knowledge is sufficient for characterization, specific sampling and analysis should be conducted during the POP test to determine compliance with the WAC. Except during the POP Test, full scale operations should not be conducted until permanent disposal is assured for residuals and secondary wastes, unless significant risk reduction by source control remediation can be achieved. For example, mixtures of mercury and organics (especially PCB's) and mixtures of PCB's and radioactive materials are known to pose significant disposal problems.

7.3 Emissions Monitoring - Stack Testing

Stack testing is part of POP Testing as specified in Section 7.1 above. For a new unit or if new equipment is added to a previously tested unit, stack testing is required; however, it is not needed each time an approved unit is set up and operated in a manner which is shown to be similar to previous test runs. Stack testing is required each time a new type of waste is being treated.

Initial stack testing parameters should include:

- constituents of concern[25]
- HCl (if applicable)
- other acid gas (if applicable)
- total hydrocarbons
- particulates
- visible emissions
- carbon monoxide (CO)
- oxygen
- metals (including mercury if applicable)
- products of incomplete combustion (PIC)/degradation, reaction, oxidation products

[25] Constituents of concern are constituents present in the soil or media prior to treatment Principal Organic Hazardous Constituent (POHCs).

(e.g., dioxins/furans)[26]

- radionuclides (for mixed waste)

Sites with soils having elevated background or metals from other sources should undergo risk screening for metals emission. This is especially important when chlorinated compounds are also present in the untreated waste stream, as the presence of chlorine may result in metal volatilization at lower temperatures than anticipated. In this case, samples representing the highest concentration of metals should be collected from the site for the screening.

Stack monitor detection instruments for radionuclide contaminants in the stack are available. Probes can be installed in the stack through the stack walls. The results of the testing can be compared with the required standards or the calculated projections.

See Sections 1.4 through 1.6 for additional notes on special conditions for dioxins/furans, mercury, and mixed waste.

7.4 Emission Monitoring - Continuous Emission Monitors (CEM)

In keeping with the EPA recommendations presented in the draft Superfund Remedy Implementation Guide, CEMs should include:

- oxygen
- carbon monoxide
- total hydrocarbons
- carbon dioxide
- mercury vapor

Other parameters may be required on a case by case basis, based on the design of the unit. For carbon adsorption units with duplicate carbon, breakthrough monitoring is required.

For mixed waste treatment units, strict operating procedures shall be implemented for radioactivity air pollution control devices. Constant operation in the configuration demonstrated in the POP test is mandatory. Prior to each waste material being fed to the unit, calculations shall be made to demonstrate that based on the radioactivity content of the feed, and the demonstrated DF for the

[26] If precursors of dioxins and furans such as chlorinated aromatics exist in the feed stream, sampling may be required. Sampling during performance tests should not be required continually. However, if the potential for presence of dioxins/furans is high, additional sampling may be necessary.

APC system, radioactive air emissions will be less than prescribed limits for both concentrations and dose. Frequent grab sampling to demonstrate acceptable air emissions level is also recommended, at least once per week and after every maintenance procedure performed on a radioactivity APC device.

7.5 Sampling and Analytical Methods

Stack testing methodologies shall be as specified in 40 CFR Part 60, Appendices A and B, or SW846.

7.6 Sample QA/QC

All QA/QC required by each specific stack sampling or analytical method shall be completed. Lab QA/QC summary documentation (including chain of custody and summary of any deviation from the QA/QC specified by the method)should be submitted with analytical results. Ultimate responsibility for QA/QC documentation belongs with the responsible party. However, the responsible party may contract with another entity, such as an analytical laboratory, to house the actual QA/QC data.

8.0 WATER DISCHARGE REQUIREMENTS

The operation of some treatment equipment may generate various types of water. Possible sources of water generation include condensate from the treatment system, storm water runoff, noncontact cooling water and soil stockpile leachate. All such water shall be collected; such water shall be treated, recycled or discharged in accordance with applicable regulations. If process water is used to remoisturize soil, treatment verification sampling should occur after remoisturization. Any excess water which is generated shall be disposed in accordance with individual state requirements. In general, water can be disposed at a permitted off-site commercial facility, a publicly owned treatment works (POTW) or on-site in accordance with a National Pollution Discharge Elimination System (NPDES) permit.

9.0 OPERATIONS RECORD KEEPING

The following records should be maintained on site or at other approved location:

- Summary of waste treatment verification sample results

- Operating logs, including
  - CEM records or logs
  - Shutdown events included in Section 6.4
  - Monitoring parameters included in Section 6.3

• Documentation on the retreatment or disposal of failed batches

10.0 GENERAL QA/QC

An independent certified laboratory should be required for all analytical testing for environmental media including air, soil and water. Labs need specific certification for radionuclides. Their licenses must be checked for the quantity/limit of a particular radionuclide the lab can accept at any one time. An in-house certified laboratory may be used if at least 10% of the samples are verified by an independent certified laboratory. These provisions apply to both mobile and fixed laboratories. For DOE sites, an onsite lab may be used. The in-house lab might also need to be certified for radionuclides.

11.0 HEALTH AND SAFETY

A written Health and Safety Plan shall be developed and implemented in accordance with Occupation Safety and Health Administration (OSHA) regulations 20 CFR 1910.120, the Hazardous Waste Operations and Emergency Response Rule.

The plan shall address the following elements:

Key Personnel
Health and Safety Risks
Training
Protective Equipment/Clothing
Medical Surveillance
Spill Containment
System Maintenance Safety
Air Monitoring
Site Control
Decontamination
Emergency Response
Confined Space Entry
System Operation Safety

For situations involving mixed waste, add the following elements:

Radiation Monitoring
Exposure Times (Operating Times)
Radiation Work Permit Program to control all tasks with exposure potential
Pre-operations Verifications Checks

12.0 CONCLUDING REMARKS

Because various states have taken diametrically opposed positions on certain issues (e.g., “Is a thermal desorber/afterburner classified as an incinerator?”, etc.), the LTTD Work Team does not endorse one type of unit over the other and does not attempt to determine whether any particular unit is acceptable either from a public or an individual state regulatory standpoint. Instead, the Work

Team endeavored to develop a set of technical guidelines which would provide sound technical/engineering guidance to many different configurations of thermal desorption systems.

The LTTD Work Team members developed a draft version of this technical guidelines document during facilitated conference calls and breakout sessions at full ITRC meetings. The draft was then circulated to all ITRC states, as well as interested stakeholders for review and written comment. Subsequently, the Work Team convened by conference call, discussed each comment that was received, and incorporated many of the suggested revisions into this final version of the document. This document is being submitted to ITRC states for their concurrence, using the process outlined in Section 12.1.

12. 1 ITRC Acceptance of the LTTD Work Product

In order to make the work products as useful as possible, the ITRC members have developed a process for member states to indicate their level of acceptance and intent to use these work products. When a work product, such as the thermal desorption regulatory guidelines document, has been finalized by the work team, it is then distributed to the ITRC point of contact (POC) for each member state. The state POCs take the documents back to their home states and distribute copies to the various heads of their regulatory agencies. "Acceptance" of the work product is defined by each state (i.e., an agency or division may indicate approval of each section of the document or the document as a whole at the following levels:

Level A - We agree that the requirements/guidelines are appropriate and commit to using them to the maximum extent feasible.
Level B - We agree that the requirements/guidelines are appropriate; however, we have an organizational, regulatory, policy, or statutory conflict. (Please indicate what the conflict is).
Level C - We agree conceptually with the requirements/guidelines and will consider using them in a test mode.
Level D - We do not believe the requirements/ guidelines are appropriate. (Please indicate the reasons why.)

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APPENDIX A

Acronyms

ACRONYMS

ALARA	As Low As Reasonably Achievable
APC	Air Pollution Control
API	American Petroleum Institute
ARAR	Applicable or Relevant and Appropriate Requirement
ASME	American Society of Mechanical Engineers
ASTM	American Society of Testing and Materials
AWWA	American Water Works Association
BNA	Base/Neutral/Acid
CAMU	Corrective Action Management Unit
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CEM	Continuous Emissions Monitor
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
CSCA	Controlled Surface Contamination Area
DCA	Dichloroethane
DCE	Dichloroethene
DF	Decontamination Factor
DRE	Destruction/Removal Efficiency
DOE	Department of Energy
EPA	Environmental Protection Agency
GC/ECD	Gas Chromatograph/Electron Capture Detector
GC/MS	Gas Chromatograph/Mass Spectrometer
HEPA	High Efficiency Particulate [filters]
Hg	Mercury
ITRC	Interstate Technology Regulatory Cooperation (Work Group)
LDR UTS	Land Disposal Restriction Universal Treatment Standard
LEL	Lower Explosive Limit
LLW	Low Level Waste
LTTD	Low Temperature Thermal Desorption
MDL	Minimum Detection Limit
NRC	Nuclear Regulatory Commission

NORM	Naturally Occurring Radioactive Material
NPL	National Priority List
OSHA	Occupational Safety and Health Administration
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PCE	Perchloroethylene
PIC	Products of Incomplete Combustion
POC	Point of Contact
POHC	Principal Organic Hazardous Constituent
POP	Proof of Process
POTW	Publicly Owned Treatment Works
QA/QC	Quality Assurance/Quality Control
RADNESHAPS	Radionuclide National Emission Standards for Hazardous Air Pollutants
RAM	Radioactive Materials
RCRA	Resource Conservation and Recovery Act
SAAM	Selective Ambient Air Monitor
SAR	Safety Analysis Review
TCE	Trichloroethylene
TCLP	Toxicity Characteristic Leaching Procedure
TDU	Thermal Desorption Unit
TPHC	Total Petroleum Hydrocarbons
TRPH	Total Recoverable Petroleum Hydrocarbons
TRU	Trans-uranic
TSCA	Toxic Substances Control Act
TSD	Treatment, Storage and Disposal
UTS	Universal Treatment Standards
WAC	Waste Acceptance Criteria
WAP	Waste Analysis Plan
VO	Volatile Organic
VOC	Volatile Organic Compound

APPENDIX B

Suggested Outline of
Cost and Performance Report
for Thermal Desorption

**SUGGESTED OUTLINE of
COST and PERFORMANCE REPORT
for THERMAL DESORPTION**

1. Executive summary

2. Site information

3. Background
   a. Contaminant Location and Geologic Profile
   b. Contaminant Characterization
   c. Soil/waste characteristics affecting treatment cost or performance

4. Treatment System Description
   a. Thermal desorption system description and operation
      -Detailed Description
      -Automatic Feed-Cutoff Conditions
   b. Operating parameters affecting treatment cost or performance
   c. Project timeline

5. Treatment System Performance
   a. - Cleanup Goals/Standards
   b. - Treatment Performance Data
      -Test Run Data Summary
      -Full-scale Sustained Run Data Summary
   c. - Performance Data Assessment
   d. - Performance Data Completeness
   e. - Performance Data Quality

6. Treatment System Costs
   a. - Procurement Process
   b. - Cost Data Quality
   c. - Treatment Cost Elements
   d. - Before Treatment Cost Elements
   e. - Post Treatment Cost Element

7. Observations and Lessons Learned
    a. Cost Observations and Lessons Learned
    b. Performance Observations and Lessons Learned

8. References

9. Appendix

    A. Treatability Study Results (if applicable)
        - Objectives
        - Test Description
        - Performance Data
        - Lessons Learned
        - Full Scale Treatment Activity (soil data)
    B. Test Run Data
    C. Full Scale Treatment Activity Soil Data

APPENDIX C

June 12, 1998 Letter from EPA
Addressing the Distinction between
Thermal Desorbers and Incinerators

June 12, 1998

Mr. Parker E. Brugge
Patton Boggs, L.L.P.
2550 M Street, N.W.
Washington, D.C. 20037-1350

Dear Mr. Brugge:

This letter is in response to your April 7, 1998, letter seeking clarification on the distinction between thermal desorbers and incinerators. Under the U.S. Environmental Protection Agency (EPA) Resource Conservation and Recovery Act (RCRA) regulations (40 CFR 260.10), thermal treatment units that are enclosed devices using controlled flame combustion, and that are neither boilers nor industrial furnaces, are classified as incinerators subject to regulation under 40 CFR Part 264, Subpart O. Thermal treatment units that do not use controlled flame combustion, and that are neither boilers nor industrial furnaces, are classified as "miscellaneous units" subject to regulation under 40 CFR Part 264, Subpart X.

EPA regulations do not define "thermal desorber", but the term generally applies to a unit that treats waste thermally to extract the contaminants from the matrix. A thermal desorber utilizing controlled flame combustion (e.g., equipped with a directly fired desorption chamber and/or a fired afterburner to destroy organics) would meet the regulatory definition of an incinerator. On the other hand, a thermal desorber that did not use controlled flame combustion (e.g., equipped with an indirectly heated desorption chamber and the desorbed organics were not "controlled"/destroyed with an afterburner) would be classified as a "miscellaneous unit".

With regard to the September 1993 Presumptive Remedy guidance entitled: "Presumptive Remedies: Site Characterization and Technology Selection for CERCLA Sites with Volatile Organic Compounds in Soils" (Directive Number 9355.0-48FS) that you mentioned, EPA identified thermal desorption and incineration as the second and third preferred technologies, respectively. The intent of the guidance is that units that can be generally described as thermal desorbers, whether or not they are also incinerators, are second in the preference list. However, if a thermal desorber that meets the RCRA definition of incinerator is used to treat hazardous waste at a CERCLA site, the unit must meet RCRA's incinerator standards. EPA developed the preferential order set out in this guidance based on historical patterns of remedy selection and EPA's scientific and engineering evaluation of performance data on technology implementation. There was no intent implied or stated in the Presumptive Remedy guidance that the preferential order was based on the temperature of operation; the guidance does not limit the thermal desorbers technologies to those that are low-temperature thermal desorbers.

We appreciate that as technologies evolve, the distinctions between units often become blurred, and, in the case of thermal desorbers, may fall within two separate classifications depending on the design of the unit. Classification of a "thermal treatment" unit, however, is defined by 40 CFR 260.10.

Both the RCRA regulatory framework and the CERCLA remedy selection process provide adequate flexibility to ensure that the unit is operated in a protective manner and that there is adequate and informed public participation. If you have any further questions, please contact either Andrew O'Palko, Office of Solid Waste, at (703) 308-8646 or Robin Anderson, Office of Emergency and Remedial Response, at (703) 603-8747.

Sincerely,	Sincerely,
signed by Elizabeth Cotsworth	**signed by Elaine Davies for Stephen Luftig**
Elizabeth Cotsworth Acting Director Office of Solid Waste	Stephen D. Luftig Director Office of Emergency and Remedial Response

cc: Andrew O'Palko, OSW
Bob Holloway, OSW
Robin Anderson, OERR
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Superfund Regional Response Managers
RCRA Senior Policy Advisors

APPENDIX D

EXAMPLE
Summary Matrix of
State Acceptance of
Thermal Desorption Work Product

TABLE D-1
Summary of Verbal/Written Indications of State Concurrence
as of __________

Level A - We agree that the requirements/guidelines are appropriate and commit to using them to the maximum extent feasible;
Level B - We agree that the requirements/guidelines are appropriate; however, have an organizational, regulatory, policy, or statutory conflict. (Please indicate what the conflict is).
Level C - We agree conceptually with the requirements/guidelines and will consider using them in a test mode; or
Level D - We do not believe the requirements/guidelines are appropriate. (Please indicate the reasons why.)

STATE	Total Document "Level A"	Air Quality "Level B" All Others - "Level A"	Mixed for specified sections	Total Document "Level B"	Total Document "Level C"	Nonconcurrence for one or more sections "Level D"	Status of concurrence process
CA							
CO							
CO (UST)							
DE							
FL							
IL							
KS							
KY							
LA							
MA							
MD							
NE							
NJ							
NM							
NV							
NY							
OH							
OR							
PA							
TN							
UT (UST)							
UT (AIR)							
WA							

APPENDIX E

ITRC Contacts, Information and User Survey

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